FRACTURES AND DISLOCATIONS
IN GENERAL PRACTICE

# THE GENERAL PRACTICE SERIES

FRACTURES AND DISLOCATIONS By JOHN P HOSFORD M.S (Lond.) F.R.C.S Surgeon, St Bartholomew's Hospital, etc Second Edition, revised by W D COLTART M.B B S.(Lond.) F R.C.S Assistant Orthopædic Surgeon St. Bartholomew's Hospital With 87 illustrations. Demy 8vo

CARDIOVASCULAR DISEASE IN GENERAL PRACTICE. By TERENCE EAST M.A.(Oxon.) M.D., F.R.C P (Lond.) Physician and Physician in-Charge Cardiological Department King's College Hospital Examiner in Pathology Conjoint Board, etc With 34 illustrations. Third Edition. Demy 8vo 16s. net.

COMMON SKIN DISEASES By A. C. ROXBURGH, M D., F.R C.P Emeritus Physician for Diseases of the Skin and Lecturer on Diseases of the Skin, St Bartholomew's Hospital etc. Eighth Edition. With 8 coloured plates and 212 illustrations in the text Demy 8vo 21s. net

THE SYMPTOMATIC DIAGNOSIS AND TREATMENT OF GYNÆCOLOGICAL DISORDERS. By M MOORE WHITE M.D (Lond.) M.B B.S F.R.C.S (Eng ), Surgeon-Specialist Three Counties Emergency Hospital late First Assistant Gynæcologist Royal Free Hospital Second Edition. Demy 8vo 16s. net

EAR, THROAT AND NOSE By J DOUGLAS MCLAGGAN F.R.C.S Surgeon in Charge of the Ear Throat and Nose Department Royal Free Hospital Surgeon Central London Throat and Ear Hospital, etc Second Edition With plates and illustrations in the text.
*In preparation.*

THE CONDUCT OF LIFE ASSURANCE EXAMINATIONS By E M BROCKBANK, M B.E. M.D (Vict.) F R.C P Honorary Consulting Physician, Royal Infirmary Manchester Second Edition. Demy 8vo 12s. 6d net.

MEDICAL DIAGNOSIS Some Clinical Aspects. By S L. SIMPSON M.A. M.D (Camb ) M.R C P (Lond ) Physician Willesden General Hospital Assistant Physician, Princess Louise Kensington Hospital for Children. Demy 8vo 10s. 6d. net.

CHEST DISEASE IN GENERAL PRACTICE, with Special Reference to Pulmonary Tuberculosis. By PHILIP ELLMAN M.D M.R.C.P Physician in Charge of the Tuberculosis and Chest Clinic County Borough of East Ham With a Foreword by PROF S LYLE CUMMINS, C.B C.M.G M.D With 132 illustrations. Demy 8vo 15s. net.

AFFECTIONS OF THE EYE. By R. LINDSAY REA, M.D F.R.C.S. Ophthalmic Surgeon, West End Hospital. With 7 coloured plates and 33 other illustrations. Demy 8vo 10s. 6d. net

**LONDON: H K LEWIS & Co Ltd., 136 Gower Street, W C.1**

GENERAL PRACTICE SERIES

# FRACTURES AND DISLOCATIONS IN GENERAL PRACTICE

BY

JOHN HOSFORD

M S Lond F R C S

SURGEON TO ST BARTHOLOMEW'S HOSPITAL

SECOND EDITION REVISED BY

W D COLTART

M B B S Lond F R C S

ASSISTANT ORTHOPAEDIC SURGEON TO

ST BARTHOLOMEW'S HOSPITAL

*WITH EIGHTY SEVEN ILLUSTRATIONS*



LONDON

H K LEWIS & Co Ltd

1949




THIS BOOK IS PRODUCED
IN COMPLETE CONFORMITY WITH THE
AUTHORISED ECONOMY STANDARDS



*Printed in Great Britain*
*for H K Lewis & Co Ltd London*
*by The Whitefriars Press Ltd London and Tonbridge*

# PREFACE TO THE SECOND EDITION

A STUDENT of fractures in these days cannot escape the influence of three men Sir Robert Jones Lorenz Böhler and Sir Reginald Watson-Jones Robert Jones who spread the principles of orthopædics and first directed attention to the relationship between activity and healing Bohler who emphasized the significance of early diagnosis and reduction of fractures under X ray control and by his improvements in plaster technique produced a comfortable light and effective splint in which functional activity of the limb could be restored in the earlier stages of treatment Watson-Jones who apart from his pioneer work in the description of many fractures has done so much to explain the teachings of Jones and Böhler to the English speaking world

There is no desire to escape the influence of these three but only to acknowledge it with gratitude whenever it may appear in this book

Since 1939 when this volume was first published there has been considerable expansion of what is known as Fracture Organisation. It is now well and widely recognised that in order to treat a patient with a fracture in an adequate manner certain facilities are necessary

The apparatus for X ray photography must be easily available so that diagnostic films may be taken early and without disturbance An X ray is usually required in the operating theatre or plaster room when a fracture has been reduced and the plaster has been applied to the limb During the after treatment of most fractures regular X ray examination is essential so that any recurrence of displacement may be discovered in good time

The majority of fractures are splinted nowadays in plaster For this method to be successful some experience in the technique of applying a plaster cast is most important A great deal of harm may be done by a badly applied cast

not the least harmful effect being delay in union of the fracture

Finally the patient must be taught at all stages of treatment to regain the use of his injured limb and must eventually be restored to the fullest possible economic efficiency For this objective a Physiotherapy Department is an advantage and indeed a full course of rehabilitation at a special centre may be required.

Because of the need for all these facilities the treatment of fractures is at the moment passing from the hands of general practitioners and most patients are now cared for in the Fracture or Accident Departments of Hospitals However the general practitioner still remains in contact with his patient and with his patient s relatives and requires to know what is going on, even if he is no longer in charge of the technical procedures involved

Revision has been undertaken with this change of circumstances in mind It is hoped again that the book will prove of value to general practitioners rather by explaining what is happening in the treatment of fractures than by supplying detailed instructions for what should be done Every effort has been made to keep the book small and to avoid as far as possible that tabulation which so useful to the student is at the same time so dull for reading at the fireside It may seem that illustration has been sparse but for reasons of size this is inevitable

Grateful acknowledgments are due to the Surgical Staff and X ray Department at St Bartholomew s Hospital for the use of skiagrams to Dr Russell Grant who has made further line drawings to Dr John Napier for his photography and to Mr R S Henderson for so kindly reading proofs

A complete chapter on Fractures of the Face and Jaws has been written and illustrated by Mr T Cradock Henry

Finally it is once again a pleasure to thank Messrs H K Lewis for their almost unending patience

W D C

LONDON
MARCH 1940

# PREFACE TO THE FIRST EDITION

I CAN answer the question why has yet another book on Fractures' been written by saying that it is in response to the request of a number of students and recently qualified men

An attempt has been made to produce a book which gives more practical help and detail regarding fractures than appears in the ordinary textbooks of general surgery but yet is not nearly so long as many of the complete treatises on the subject It is hoped that by this means the book will prove of value not only to the general practitioner who has occasion to treat fractures from time to time but also to undergraduates working for their final examination in surgery With this aim in view details of open operations on fractures and complicated methods of skeletal traction have been omitted

This is not intended to be a complete textbook and if the reader notices certain omissions or what appears to be a disproportion in the space devoted to certain subjects he can be assured that this has been done after careful consideration

Many satisfactory methods of treating fractures have been used in the past and are in use now and no claim is made that any one method is the best but for the sake of simplicity and to save the reader the necessity of trying the pros and cons of various methods only one is given in the description of most of the fractures of individual bones It must always be remembered that the good result of treating a fracture depends not one jot so much on the method used as on the individual and continued personal care and supervision that is given guided by simple anatomical physiological and mechanical principles

The methods described are ones which in use have been found satisfactory and simple No particular originality is

aimed for any of them and many follow those used by Bohler of Vienna to whose practice and writings the medical profession in this country undoubtedly owes much

In an appendix at the end of the book are brief accounts of a few surgeons of the past whose names are household words in the fracture world

The illustrations consist largely of untouched reproductions of skiagrams These are used instead of the rather popular line drawings of skiagrams because in practice one has to interpret original skiagrams and not read simple diagrams

I am greatly indebted to my surgical colleagues at St Bartholomew's Hospital and the staff of the X ray Department for permission to make use of skiagrams My thanks are also due to Dr Russell Grant who kindly made several of the original line drawings and took photographs The editors of the *St Bartholomew's Hospital Reports* and the *Lancet* have graciously given me the blocks from certain of my articles

Finally it is a pleasure to thank Messrs H K. Lewis & Co for their remarkable patience during months of waiting for the manuscript and for their unending courtesy help and advice

J H

*January 1939*

# CONTENTS

## GENERAL



## SPECIAL

the lower third of the tibia and upper end of the fibula, these being the weakest parts of the bones

## Types of Fracture

Fractures may be open or closed complete or incomplete impacted comminuted or complicated they may be described also according to their direction in a bone

Open and Closed If the skin is not injured and the fracture does not communicate with the exterior it is called a *closed fracture* If there is a skin wound whereby the fracture is in communication with the outside air it is called an *open fracture*. The presence of skin wounds over a bone which is fractured does not constitute an open fracture unless there is a communication through the soft tissues from the skin to the bone the fracture is a closed one

Open fractures most commonly occur as a result of direct violence the skin being lacerated from *without* by the fracturing force In spiral fractures due to indirect violence there is often a sharp pointed fragment of bone which perforates the skin from *within* This is most commonly seen in the tibia Infection of the bone is the great danger in an open fracture It is obviously more likely to occur when the skin is injured from without as infected material is carried in at the time of the injury It is not necessary for the skin to be injured to have an open fracture the bone may communicate with the exterior through a tear in the mucous membrane *e.g* the mandible through the buccal mucosa

The old terms compound and simple for open and closed are not so accurately descriptive

Complete and Incomplete When a bone is broken so that there are two or more separate fragments it may be described as being *complete* Sometimes however a fracture is *incomplete* in that the above has not occurred examples of this are green-stick, fissured and compression fractures

Not infrequently when a child sustains a fracture the bone is not broken right through it is only bent This is known as a green stick fracture There may be bending only with no actual solution of continuity in any part of the cortex of the bone (Fig 27) In other cases where there is angulation

at the site of fracture, the cortex on one side of the bone (usually the convex) is fractured so that there is separation, while on the concave side the bone is only bent After the age of twenty, as the bones have grown less supple and more brittle, it is rare to see a green stick fracture

A fissured fracture is one in which a crack occurs in a bone without actual separation of a fragment In the case of the long bones a fissured fracture is usually longitudinal. Fissured fractures are also seen in the skull

A bone may be fractured by being crushed there being no separate fragments, it is a variety of incomplete fracture This condition is seen typically in the bodies of vertebræ and in the os calcis and is described as a compression fracture

IMPACTED An impacted fracture is one in which one fragment is driven into the other so that it penetrates some distance into it It usually occurs as a result of a fracture by indirect violence common examples being a Colles's fracture at the lower end of the radius, and a fracture at the junction of the head of the humerus with the upper end of the shaft In each case the shaft of the bone may be driven into the cancellous tissue composing the end of the bone With impaction there is of necessity some shortening in the length of the bone

COMMINUTED When a bone is broken into more than two fragments the fracture is described as comminuted There may be three or four large fragments or innumerable little ones A comminuted fracture is usually more difficult to reduce and splint satisfactorily than one in which there are but two fragments There is also a danger that one or more of the fragments may be completely separated from periosteum and so have their blood supply imperilled

## Direction of Fracture

*Transverse* The bone is fractured transversely This may occur as the result of direct or indirect violence

*Oblique* Oblique fractures are usually due to indirect violence The length of fractured surface is greater than in transverse fractures and firm union takes place sooner

*Spiral* When there is a twisting strain on a bone the line

of fracture is often spiral. This is most commonly seen in the lower half of the shaft of the tibia

## Displacement

In describing displacement it is customary in the case of the shafts of the long bones to refer to displacement of the

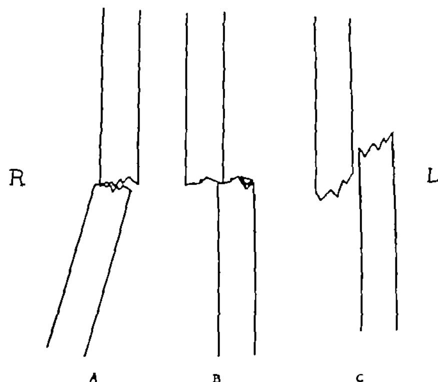



FIG 1 Characteristic displacement of fractures.
A. Angulation.
B Lateral displacement.
C Overlapping

distal fragment in relation to the proximal, whereas at the ends of long bones it is to the displacement of the smaller end fragment that reference is made

*Lateral Displacement* The distal fragment may be displaced either anteriorly or posteriorly to the inner or to the outer side. Sometimes the displacement is only slight so that the fractured ends of the bones are still in contact at others they are no longer in contact the bone being displaced its whole width to one side

*Overlapping* This is a natural sequence of lateral displacement when the latter is of such a degree that the ends of the fragments are not in contact the pull of the muscles causes the fragments to overlap and shortening of the bone follows

*Angulation* Here the two fragments form an angle with each other instead of being in a straight line or parallel It is important in describing such a fracture to make quite clear in what direction the angle faces Forward or medial angulations are indefinite descriptions and such descriptions as ' angulation convex anteriorly or ' convex medially ' should always be used It is customary to imply ' convex ' if it is omitted

*Rotation* This form of displacement is very important because it is so easily overlooked and its presence may not be appreciated until union has occurred Rotation is more easily observed from the limb itself than from the X rays The distal fragment is rotated on its long axis compared with the proximal fragment if union occurs in this position the whole limb distal to the fracture will be rotated either inwards or outwards as the case may be and in the case of the lower limb at any rate will cause considerable displacement

Following some fractures there is no displacement of the fragments In others displacement may be slight or may be severe Slight displacements may be of considerable significance when joint surfaces are involved but can often be ignored in other cases Gross displacement will always call for reduction but it should be remembered that it is much more important to overcome angulation or rotation than lateral displacement or overlapping

## Complicated Fractures

In nearly all fractures there is some unimportant injury to muscles and adjacent small blood vessels but if there is an injury to a main vessel or nerve or if tendons are divided a joint invaded or a viscus penetrated the fracture is described as complicated

of fracture is often spiral. This is most commonly seen in the lower half of the shaft of the tibia

### Displacement

In describing displacement, it is customary in the case of the shafts of the long bones to refer to displacement of the

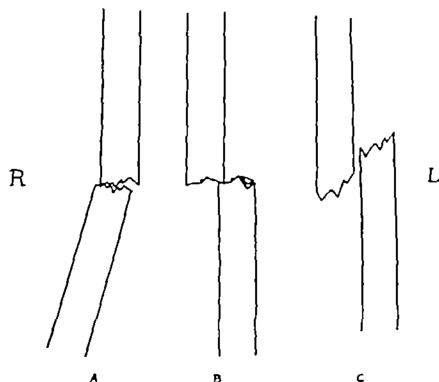



Fig 1 Characteristic displacement of fractures.
A. Angulation.
B Lateral displacement.
C Overlapping

distal fragment in relation to the proximal, whereas at the ends of long bones it is to the displacement of the smaller end fragment that reference is made

*Lateral Displacement* The distal fragment may be displaced either anteriorly or posteriorly to the inner or to the outer side Sometimes the displacement is only slight so that the fractured ends of the bones are still in contact at others they are no longer in contact the bone being displaced its whole width to one side

being too severe to allow him to use the limb With regard to the converse, a fracture is not excluded if there is no loss of function because with an impacted fracture normal use of the limb may be made On more than one occasion, following a fracture of the neck of the femur, a patient has been able to walk, complaining only of some pain in the hip

*If deformity* of a limb is present following an accident, it is an almost sure sign that either a fracture or dislocation is present, but care must always be taken to inquire whether the limb was straight and normal before the accident so that some congenital or previously acquired deformity may not be overlooked If the deformity is in the form of angulation it is readily seen. In the case of a lower extremity the only visible deformity may be external rotation, and this is easily seen by noting that the leg is rolled out with the outer side of the foot resting on the couch Shortening of the limb may be the only deformity present and this may be overlooked if it is not made an invariable rule to measure a limb in a case of suspected fracture

With any superficially placed fracture a considerable degree of *swelling* appears quickly Swelling is mainly due to diffusion of blood into the tissues, and in the case of a fractured femur for example, the swelling may reach enormous proportions In the case of the thigh the effusion of blood is controlled to a certain extent by the thick strong fascia lata so that bruising and fracture blisters are not so prominent and swelling extends over the whole length of the thigh In the case of a fracture-dislocation of the ankle joint where the bones are more superficial, *bruising* occurs early and fracture blisters appear soon, but the swelling remains more localised to the ankle Swelling is conspicuously absent on physical examination in the case of several important and at the same time serious *fractures* Examples of this are fractures of the neck of the femur and fractures of the body of a vertebra In the former case the spread of the effusion of blood is controlled by the capsule of the hip joint, and although the joint itself is slightly distended it is so deeply placed that it makes little visible swelling on the surface A fractured vertebral body is so

## CHAPTER II

## SIGNS SYMPTOMS AND DIAGNOSIS

THE characteristic symptoms and signs of a fracture which may be present are

(1) History of an injury
(2) Pain
(3) Loss of function.
(4) Deformity
(5) Swelling
(6) Bruising
(7) Tenderness
(8) Abnormal mobility
(9) Crepitus
(10) X ray appearances

In almost every case of fracture there is a definite *history of injury* exception occurs to this in the case of a pathological fracture for here a bone breaks with such ease that a patient may be doing nothing more than stepping off a bus or getting out of bed when a leg gives way under him Where there is a definite history of injury a detailed account of it will sometimes help in making a diagnosis of the exact position of the fracture

*Pain* is prominent in every fracture unless there is a loss of function of the sensory nerves supplying the part This may occur in certain neurological diseases but it is more often seen in patients who are drunk It has often been possible to set a fracture without the need for an anæsthetic in a patient who is still under the influence of alcohol

Although *loss of function* is described as one of the characteristic signs of a fracture it is not as a rule of great help in the diagnosis of fractures If a patient falls and says he cannot use one of his legs it certainly suggests that a fracture is present but more often he complains of the pain

will give a crepitus on movement The grating of the rough surfaces of an osteo arthritic joint must not be mistaken for the crepitus of a fracture After a little experience each of these types of crepitus will be readily distinguishable

## X-ray Appearances

Although an X ray examination should be made in every case of injury where there is any possibility of a fracture being present an attempt should always be made to arrive at an accurate diagnosis on clinical grounds

Skiagrams should be taken both before and after reduction of the fracture and also at intervals later while union is occurring But expense and inaccessibility do not always allow of the realisation of this ideal But if repeated skiagrams cannot be obtained the most important as well as the most useful is that taken when the fracture has been reduced and immobilised in splints

It is always advisable for the practitioner in charge of the case to see skiagrams for himself and not to rely on a written report for it is sometimes very difficult to describe in writing the exact displacement of fragments and it is very easy to misinterpret a report whereas a glance at X ray films will often be sufficient to show exactly the displacement at the fracture

It is necessary to emphasise here the importance of having skiagrams of every fracture taken in at least two different planes Occasionally in an antero-posterior view a fracture which is obvious when seen from the lateral aspect may be overlooked and frequently the position of fragments may appear good when seen from one direction while from another there is an obvious deformity In a few parts of the body it is difficult to take satisfactory views in two planes While an antero posterior view of the pelvis will show a fracture clearly the lateral view is of little value owing to the two os innominata overlapping one another But in the case of the lower part of the sacrum and the coccyx a lateral view may be helpful in showing a fracture With modern technique it is possible to obtain an adequate lateral view of the neck of the femur so that

deeply placed that no swelling is at first discoverable, nor is there much later

*Tenderness* is a constant accompaniment of a fracture unless pathological or alcoholic analgesia is present Local tenderness is one of the most important diagnostic signs of a fracture When examining for this only one finger should be used and not the grasp of the whole hand If this examination is carried out carefully it is of the greatest value in determining the presence of but more particularly in excluding a fracture With an injury to the ankle and pain localised to the outer side careful pressure with one finger along the outer side of the fibula can usually determine almost as accurately as X rays, whether there is a fracture of this bone or a tearing of the external lateral ligament For a fracture of a bone placed deeply in muscles as in the case of the femur this one-finger test is not of great value but for superficially placed bones it is of the greatest help A subperiosteal hæmatoma from a direct blow on the bone will also give localised tenderness but it is usually a little more diffuse than in the case of a fracture

By *abnormal mobility* is meant that either there is mobility of a joint in an unusual direction or that there is movement in a limb at a point where normally there is no joint If the latter is the case it is a certain sign of fracture In the former case there may be either a fracture of the articular surfaces or a severe tearing of ligaments It is often difficult to determine the presence of abnormal mobility where there is a lot of swelling and the fracture is very close to a joint

*Crepitus* is one of the classical signs of fracture The ordinary hard crepitus is due to the grating together of fractured surfaces of bone With a separated epiphysis the grating felt by the examining hand is somewhat different and may be described as soft crepitus Crepitus causes the patient considerable pain, and for this reason as well as because it may damage the tissues further it should not be tested for more than is absolutely necessary There are other causes of crepitus than the grating together of fractured bone surfaces A dry teno-synovitis and sometimes old blood clot

a minute crack in the cortex which with the naked eye may be overlooked Another difficulty arises in diagnosis in connection with the various developmental abnormalities in bones In certain places there are well known developmental errors in which two parts of a bone have failed to unite Such separated fragments are seen in the os trigonum at the back of the astragalus in the transverse processes of the first lumbar vertebra, the os tibiale externum on the tarsal



FIG 2 Bipartite patella. This characteristic but not very common congenital abnormality of the patella, where the upper and outer part of the bone has a separate centre of ossification is sometimes mistaken for a fracture Being usually bilateral, an X ray of the other knee will confirm the diagnosis

scaphoid, the os Vesalii at the base of the fifth metatarsal the bipartite carpal scaphoid and the separated upper and outer edge of the patella (see Fig 2) When an injury occurs in any of these regions and doubt exists as to whether the separated fragment is a developmental error or a fracture help may be obtained by X raying the opposite side as errors of development are frequently bilateral If the skiagram shows detail well, doubt may also be dispelled by examination with a hand lens for this will show up a continuous though fine layer of dense cortical bone in the

deformity in a fracture of the neck may be examined in this view as well as in an antero-posterior In the shoulder region when the arm cannot be abducted from the side it may be impossible to obtain a lateral view which is of any value In this and other regions where skiagrams in different planes cannot be obtained stereoscopic views should be taken, but except in the hands of very few the interpretations of such views are not reliable when slight degrees of displacement are under consideration

If a fracture is seen on an X ray a further search of the whole film for other fractures or dislocations should be made The finding of one obvious fracture has often been the cause of overlooking a second and perhaps more important fracture or dislocation examples where this may occur are fractures of the lower end of the radius associated with fracture of the scaphoid or dislocation of the semilunar and fracture of the upper half of the shaft of the ulna associated with forward dislocation of the head of the radius

Not only is interpretation of the displacement of a fracture sometimes difficult but the actual presence of a fracture is not always easy to determine in some of the long bones particularly the radius and tibia the canal of the nutrient artery may be mistaken for a fracture In the skull the many grooves on its inner table are often confusing when looking for a fracture in an X ray The overlapping of bones *e.g* in the carpus and tarsus may lead to difficulty in determining the presence of a fracture In such cases when the presence of a fracture seems probable help may be obtained by having a view taken obliquely or at some different angle In bones which are composed of a mass of cancellous tissue such as the body of a vertebra or the os calcis it may be difficult unless an X ray film is very good to see the line of fracture running through the bone and in such cases the diagnosis may depend on the alteration in the shape of the bone rather than on the visualisation of an actual line of fracture

A hand lens is often of considerable help in determining the presence of a fracture In doubtful cases it may show up an irregularity in the internal architecture of the bone or

show a perfect alignment of the fragments of both the tibia and fibula and the possession of these views may mislead the practitioner into assuming that the fracture is undergoing union in this satisfactory position, but unless the X ray examination was made after the splint was put on instead of before and unless the splint which is put on is a close-fitting and complete plaster cast the fragments may easily have shifted their position and be in poor alignment To presume that a fracture remains in good position once it has been reduced without confirming it is to court disaster From these remarks it is clear that a skiagram should always be taken after a splint has been put on and after every time a splint is changed until union has occurred The cause of mal union in the case of many Pott s fractures is not so much a failure to reduce the fracture as a failure to maintain reduction while wooden splints or a plaster cast are being applied

For medico legal reasons if for no other, skiagrams should be taken in all cases where from the nature of an accident a fracture may be even remotely possible If there is difficulty in obtaining such X ray examination the onus of failing to have it made whether the reason be one of distance or expense should be placed on the patient or his friends The possession of a set of skiagrams may be of the greatest assistance in the witness box and a doctor is advised to keep skiagrams of all cases of fractures himself for months and even years afterwards

## Missed Fractures

Fractures may be missed either by the patient or by the doctor If care is taken in examination and good X rays are obtained a fracture is not likely to be overlooked although it may occasionally happen even when the greatest care is taken Fractures are not infrequently overlooked by the patient or the patient s parents in the case of a child and so no treatment is carried out The author has met with fractures of all the long bones in the body which have been thus missed by the patient, and have only been seen some weeks later on account either of swelling (which is usually

one case and the slightly jagged surface of a fracture uncovered by dense bone in the other

The appearance of a green stick fracture without displacement is quite typical but may be overlooked In such cases the line of fracture across the bone may not be visible but a very characteristic bulge on the surface of the bone will easily be seen if looked for with care In other green-stick fractures the more typical appearance of a crack on the convex side of the bone and a buckling up of the cortex without any actual interruption of its continuity on the concave side will be seen

In a few places in the body it is well known that a fracture immediately after an accident may not be visible but at a later date may show quite clearly, such a place is the scaphoid at the wrist When a fracture is suspected here but is not seen on immediate X ray examination the latter should be repeated after two or three weeks when as the result of slight absorption around the fracture the break may be clearly visible Actually if radiograms are taken with the wrist in several different positions a crack through the scaphoid is very unlikely to be missed

This subject cannot be left without pointing out that skiagrams may be indirectly misleading in at least two different ways Firstly the position of the fragments may appear bad in the skiagrams, though clinically their position may be satisfactory Secondly the skiagrams may show a fracture to be in excellent position whereas in fact union may be occurring with the fragments in poor alignment These two apparent contradictions are best understood by quoting examples In the first case a fracture of the femur may as regards length of the limb and straightness of the thigh as seen clinically in the antero posterior and lateral views be entirely satisfactory but X ray examination may show considerable lateral displacement If this displacement cannot be corrected the X rays may be the cause of an ill-advised open operation being undertaken when continuing with conservative treatment would have given a perfect functional as well as cosmetic result In the second case a skiagram of a severe Pott s fracture at the ankle joint may

## Chapter III

# GENERAL PRINCIPLES OF TREATMENT

Although the two main principles of reduction and fixation in splints have been carried out as long as there is any record of the treatment of fractures, there have been from time to time certain variations in the execution of these principles The old treatment of rigid fixation in splints combined with complete rest to the whole of the affected limb led to much stiffness of joints In the latter part of the last century Lucas Championnière advised early mobilisation of joints He used little or no splinting and in fact put movements and function of the limb before anatomical reduction of the fracture and fixation This treatment needed constant and very skilled massage and care of the fracture and in his hands gave excellent functional results Following his pronouncements the method of treating fractures by having removable splints and instituting early massage and movements came into common use Following this and at the present time, the principle of early massage and movements has lapsed being replaced by prolonged immobilisation, but this differs essentially from the older treatments in that actual use of the remaining parts of the limb and the rest of the body is not only allowed but encouraged The three principles of the modern treatment of fractures may be summarised as follows

(1) Accurate reduction of the fracture

(2) Continuous 'immobilisation' of the fragments until bony union has occurred

(3) Restoration of function by active use of the limb during the period of immobilisation and after the fracture has united

Active use prevents disturbance of the normal circulation of the limb, prevents atrophy of muscles and by encouraging the normal blood supply prevents atrophy and

callus) or of continued pain Fractures of the skull bodies of the vertebræ, carpal scaphoid and os calcis have all been overlooked by patients In the case of the long bones it is more often in children that the gravity of the injury is not realised, this is because the fracture is likely to be of the green-stick variety There is only slight pain at the site of fracture and the child continues to use the limb normally it is only when the parent notices the swelling of the bone that advice is sought An X ray will then reveal a green stick fracture with callus forming around it

must carry his arm in a sling or walk on crutches, or rest in bed

If the limb is used prolonged immobilisation does not lead to the stiffness of joints which used to be so much feared In the upper extremity with any fracture in the region of the wrist joint the fingers, elbow and shoulder are used from the beginning of treatment A sling is not allowed and the stiffness in the shoulder which was so often seen in old ladies who nursed their Colles s fracture in a sling for three or four weeks is not now seen since active shoulder movements have been carried out throughout the period of treatment As the fingers are moved their flexor and extensor tendons move up and down over the wrist joint and the site of fracture and act as a local and intimate form of massage. The more the patient uses the whole arm and hand while the wrist is securely immobilised the more quickly and strongly will the fracture unite also there will be less muscle atrophy and the range of movement at the wrist when the plaster is removed at the end of a month is quite surprising The arm should be put through the sleeves of clothing including the overcoat and the less notice taken by the patient of the fracture, provided the plaster remains secure the better it will be for him and all concerned Similarly for fractures in the ankle region and foot an unpadded plaster cast will hold the bones so securely that if a heel is added to the plaster the patient will be able to walk as the patient walks although the ankle is rigidly immobilised the gastrocnemii which take origin from the lower end of the femur are not at rest and do not become wasted because knee movements are taking place normally The patient is encouraged to exercise the toes by frequently dorsiflexing them the long flexor and extensor tendons will then by moving over the ankle joint massage it

As with the wrist it is surprising what a range of movement is immediately possible after removal of the plaster For a patient with determination the handicap of a leg plaster with a walking heel is not great One patient with his leg in plaster from the toes to the tubercle of the tibia drove a car 200 miles as well as spending an active holiday



FIG 3 Decalcification following disuse Marked decalcification is seen in the carpal bones following a fracture of the lower end of the forearm. Much calcium has been absorbed from these bones and they have a ghostlike appearance The exact mechanism and cause of this condition is uncertain, but it is liable to follow splintage and disuse If the forearm is splinted but use of the hand allowed and encouraged, this change in the bones is not likely to occur

hastens union of the bone The mental outlook of a patient who can use his arm or leg and be actively up and about instead of recumbent in bed is far better than that of one who

must carry his arm in a sling or walk on crutches or rest in bed

If the limb is used prolonged immobilisation does not lead to the stiffness of joints which used to be so much feared In the upper extremity with any fracture in the region of the wrist joint the fingers elbow and shoulder are used from the beginning of treatment A sling is not allowed and the stiffness in the shoulder which was so often seen in old ladies who nursed their Colles s fracture in a sling for three or four weeks is not now seen since active shoulder movements have been carried out throughout the period of treatment As the fingers are moved their flexor and extensor tendons move up and down over the wrist joint and the site of fracture and act as a local and intimate form of massage. The more the patient uses the whole arm and hand whi e the wrist is securely immobilised the more quickly and strongly will the fracture unite also there will be less muscle atrophy and the range of movement at the wrist when the plaster is removed at the end of a month is quite surprising The arm should be put through the sleeves of clothing including the overcoat and the less notice taken by the patient of the fracture, provided the plaster remains secure the better it will be for him and all concerned Similarly for fractures in the ankle region and foot an unpadded plaster cast will hold the bones so securely that if a heel is added to the plaster the patient will be able to walk as the patient walks although the ankle is rigidly immobilised the gastrocnemii which take origin from the lower end of the femur are not at rest and do not become wasted because knee movements are taking place normally The patient is encouraged to exercise the toes by frequently dorsiflexing them the long flexor and extensor tendons will then by moving over the ankle joint massage it

As with the wrist it is surprising what a range of movement is immediately possible after removal of the plaster For a patient with determination the handicap of a leg plaster with a walking heel is not great One patient with his leg in plaster from the toes to the tubercle of the tibia drove a car 200 miles as well as spending an active holiday

on the Broads Such activities are encouraged, and do nothing but good provided the plaster cast continues to hold the limb securely

Fractures of the spine provide an outstanding example of the advantages of modern treatment over the older methods A patient with a compression fracture of a vertebra is now immediately immobilised in a plaster jacket and after a few days can get up walk about and continue at light work. When, in addition exercises for the muscles of the back are carried out an almost perfect functional result will be obtained as soon as the plaster is removed There is no need to enlarge upon the advantages to the patient as regards physical comfort, mental outlook and ability to work nor upon the advantages to hospital authorities as regards saving of expense from long occupation of beds when this method of treatment is carried out

The mental outlook of patients with fractures is a most important factor in their recovery The modern method of immobilisation combined with active use of the limbs is better for the patients mental attitude towards themselves and the world for two reasons (1) Because they are not invalided nor helpless and can use their limbs (2) Because once the plaster cast is put on they are made to realise that it is then up to them to get well and they are not dependent on others for their recovery of function

## Reduction

Reduction of the Fracture It is sometimes difficult to know whether it is wise to attempt to improve the position of a fracture or whether it should be left alone Experience is the best guide There are however a few principles which help in making the decision.

(1) It is much more important that slight displacements in fractures involving articular surfaces should be corrected than in fractures at a distance from joints

(2) In the case of the shaft of a long bone a slight amount of angulation if not corrected will leave much greater deformity than slight lateral displacement

(3) It is often best to leave slight lateral displacements in

the shaft of a bone alone, as any manipulation may make the position worse

(4) Permanent shortening causes more serious disability in the case of one of twin parallel bones than of a single bone, and shortening in the lower extremity is usually more serious than in the upper

Once the diagnosis has been made and it is decided that a fracture must be reduced there is nothing to be gained by delay Until the limb has been "set" the patient will be apprehensive and uncomfortable and proper immobilisation of the fragments is not possible Until the fracture is immobilised, irritation of the tissues with reflex exudation of fluid will continue and swelling of the limb will increase The displaced bone ends may be impinging on important vessels and nerves, tendons and muscles are being stretched or crushed if the fracture involves or is near to a joint, effusion is increasing and capsular ligaments are being over stretched The very act of reduction will cause fresh bleeding around the fracture and the process of repair which may have commenced will be upset Healing will not begin until the fracture has been reduced and splinted so that, thinking purely in terms of union of the fracture any time elapsing between injury and reduction is time wasted

But the need for early and rapid action is governed by the same considerations which hold for any other surgical emergency The condition of the patient must be satisfactory proper facilities must be available and the proceedings should be under the control of an experienced surgeon.

If the patient is suffering from shock the usual measures will have to be taken to control this condition, but it has often been observed that reduction and immobilisation of fractures proves a most useful antidote to shock, and this is particularly true in fractures of the shaft of the femur Sometimes a fracture is but one of the multiple injuries to a patient and then it must take its turn in priority of treatment

With proper facilities accurate reposition of the fracture is obtained at one operation That unsatisfactory method by which a fracture is set and plaster applied but no X ray to confirm reduction is or can be taken until the next day

may condemn the patient to the ordeal of several anæsthetics and cause repeated irritation to bone and soft tissues just settling down to their reparative duties Properly the surgeon should have plenty of time the patient should be ready for a long anæsthetic and an X ray apparatus should be available at the operation As a corollary the dark room should be attached to or within easy reach of the theatre The fracture is reduced by whatever method is necessary an X ray is taken—screening is not a good practice—and a plaster cast or other means of immobilisation of the fracture applied Further X rays will show whether there has been the anticipated accurate replacement if not the plaster must be removed and the whole process of reduction repeated and repeated again if necessary until a good and satisfactory position is obtained

**Anæsthetic** For the reduction of a fracture it is essential that the patient s muscles be completely relaxed It is true that when the case is seen within a few minutes of injury or if the patient is unconscious from cerebral concussion it may be possible to reduce the fracture without an anæsthetic but these phenomena are unusual and in the ordinary run of events an anæsthetic whether general local or nerve block, will be necessary and by abolishing muscle spasm will permit the grossest displacements of bone to be overcome There is hardly any branch of surgery in which the services of an experienced anæsthetist are of more value Not only must the patient be completely relaxed but he must often be kept relaxed until the fracture has been reduced the plaster cast applied and set and until reduction has been confirmed by X rays

*General Anæsthesia* Nitrous oxide anæsthesia is not usually satisfactory when reducing and splinting a fracture It does not give a sufficient period of relaxation for the necessary manipulation to be carried out effectively and the splint put on without muscle spasm returning and causing either a redisplacement of the fragments or great difficulty in applying the splint A longer anæsthetic giving full muscle relaxation is necessary except when the manipulation is short and simple and the splint can be applied quickly

Gas oxygen and ether, or ether alone, are suitable, on the other hand evipan or pentothal sodium introduced intra venously are very good general anæsthetics for reducing fractures for there is good relaxation and both the induction and recovery are rapid

*Local Anæsthesia* The special advantages of local anæsthesia in fracture work are, firstly that a second person to give the anæsthetic is not always required and secondly that it provides a long anæsthetic for reduction under X ray control without the risks of a long general anæsthetic The disadvantages are however the risk of infecting a closed fracture and that the method is not always successful in abolishing pain this is especially so when reduction is undertaken more than twenty four hours after the fracture has occurred

A 2 per cent solution of novocain is used The addition of adrenalin is not necessary The skin over the fracture is cleaned with ether-soap and iodine or acriflavine With a fine hypodermic needle a few drops of the novocain solution are injected intradermally, raising a weal A somewhat larger and longer needle mounted on a twenty cubic centimetres syringe is then passed through the weal and down to the site of fracture the method of anæsthetising the fracture being to inject novocain into the hæmatoma surrounding it When the needle is felt to impinge against the rough fractured surface of bone the piston of the syringe is withdrawn to determine whether the needle point is in the hæmatoma If it is blood will flow back into the syringe If no blood appears three or four cubic centimetres of novocain solution are injected and the piston again withdrawn if blood-stained fluid is withdrawn the needle is in the hæmatoma If not the position of the point of the needle must be altered until the hæmatoma is reached Novocain is then injected Varying amounts are required For a Colles s fracture about twenty cubic centimetres are sufficient for a Pott s fracture up to fifty cubic centimetres are often necessary for the shaft of a long bone twenty to forty cubic centimetres are required according to the fracture and whether it is comminuted or not It is advisable

to wait for about ten minutes after the injection before manipulating the fracture

Anæsthesia lasts for about an hour or an hour and a half, so that if the X ray film taken immediately after the reduction and putting on of the splint shows that the position is not satisfactory the plaster may be removed the position of the fragments altered and a new plaster applied, without the necessity of giving a second anæsthetic

**Methods of Reduction** There are three principal ways of reducing a fractured bone One is by manipulation assisted if necessary by traction the second is by the use of some mechanical apparatus to produce more powerful and sustained traction and the third is by operation on the bone

Each method has its particular indications and their application will of course vary with individual fractures

**Manual Reduction** This is the commonest method. It is the classical method for most fractures and if reduction can be secured by this simple means the complications which so often beset the other methods will have been avoided Often it is better to accept a slight amount of displacement after a manual reduction than to resort to mechanical traction or operation in order to secure a perfect X ray picture

There are a few simple rules

The fracture must be disimpacted this can be brought about by gently increasing the deformity before endeavouring to separate the fragments

To obtain alignment the distal fragment must be brought into line with the proximal.

Manual traction will often succeed in reducing a fracture once the fragments have been disimpacted by manipulation Traction should be steady and continued for minutes rather than seconds This kind of traction will require an assistant and possibly some method of holding the proximal part of the limb fixed for example a padded canvas band round the upper arm secured to a staple in the wall. Once the fracture has been reduced traction in the long axis of the limb will hold the bones in position until a splint has been applied.

**Mechanical Traction** Some fractures more especially fractures of the shaft of the femur or the tibia and fibula are difficult to reduce by traction unless considerable force is used Once alignment or anyhow correct length, has been obtained in these fractures it may be necessary to continue traction for several weeks to prevent redisplacement However, let it be said at once that the force or weight required to reduce the fracture will always be far greater than the force necessary to maintain reduction, and if unnecessarily heavy traction is continued after the fracture has been reduced the fractured bony surfaces will be held apart (distracted) and union will be very much delayed

There are two methods in common use for obtaining traction—(1) skin traction and (2) skeletal traction

(1) Skin Traction A variety of adhesives has been used in obtaining a pull on the skin different sorts of strapping and plaster have been employed strips of gauze fixed with glue have been popular and more recently elastic adhesive strapping has come into favour The simplicity of the latter compared with the others is one of its special recommendations Elastoplast which is a most useful bandage for sticking to the skin is made in two different kinds the one is elastic in its length but not from side to side while the other is not elastic when pulled lengthways but is elastic transversely The latter Extension Elastoplast is most suitable for obtaining a pull on the skin The technique of its application for skin traction is briefly as follows a sufficient length of Elastoplast a wooden spreader four by three inches with a hole in its centre a length of cord a pulley and a weight are necessary the distance up the leg or arm from which it is necessary to obtain traction is measured the length of Elastoplast required will be twice this plus ten inches because the Elastoplast is attached to each side of the leg and sufficient is needed at the lower end to reach across the spreader as well as to allow the latter to be about three inches from the sole of the foot The wooden spreader is now placed exactly half way along the strip of Elastoplast which is held out the spreader lying lengthwise on the Elastoplast While an assistant holds the

spreader in one hand and one end of the strip of Elastoplast in the other the far end of the Elastoplast is applied to the side of the limb which if very hairy should be shaved, but otherwise is best left as it is One side having been stuck the other is then similarly attached while the assistant continues to hold the spreader it will be found easier to get the Elastoplast to lie evenly and to get the right length, if it is applied to the skin from above downwards rather than from below upwards As the Elastoplast is elastic from side to side it will be found possible to make it lie very snugly around the calf much more so than in the case of ordinary adhesive strapping The sticky side of the lower part of the Elastoplast from a point just above the malleoli should be rubbed with a pad of cotton wool so as to make it lose its stickiness A thin pad of wool or felt is placed over each malleolus to prevent pressure sores An ordinary crêpe bandage is now put on firmly and evenly over the limb from below upwards from just above the malleoli to the top of the strips of Elastoplast A cord with a knot on the end of it is then passed through the hole in the spreader and traction may be made immediately

The strips of Elastoplast should end above at the level of the fracture Twelve to fifteen pounds is about the maximum pull which the skin will stand

(2) Skeletal Traction In skeletal traction the pull is taken directly from the bone The commonest sites used are the tuberosity of the tibia and the lower end of the shaft of the tibia Sometimes and by some surgeons the lower end of the femur or the os calcis is used instead

The stainless steel pins which are inserted into the bone are of many patterns but that most convenient for use is one which is the same thickness in its whole length is circular in cross-section and has a square end to which a handle may be fitted they are often called Steinmann s pins They have the great advantage that they are rigid have a firm hold on the bone and cannot be shaken out A stirrup is used to transfer the pull from the pin to the cord The best pattern of stirrup is that used by Böhler It has a swivel at each end where it embraces the pin

Some years ago the use of Kirschner wires in skeletal traction became popular One advantage is that from the small size of their cross-section they make a small hole and do very little damage to the bone their disadvantages are that they require a special instrument for their introduction into the bone a somewhat cumbersome stirrup to keep the

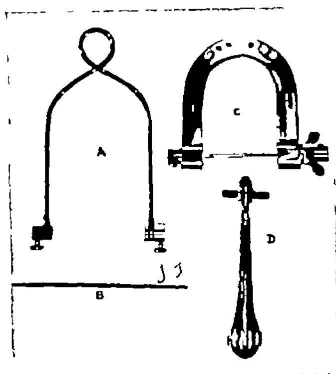



FIG. 4.—Steinmann stirrup and pin (A and B) Kirschner wire and stirrup (C) Pin introducer (D).

wire taut so that it will not bend when traction is made on it and lastly the wire may break—a most unpleasant accident

A pin or wire may be introduced under local anæsthesia A 2 per cent solution of novocaine is used It must be injected subcutaneously and also under the periosteum which is a very sensitive structure although the bone itself is insensitive to the introduction of a pin In the case of the tuberosity of the tibia or os calcis ten to twenty cubic centimetres of the solution are necessary It is advisable to inject the solution over a slightly larger area on the side of

exit of the pin than of entry When introducing a Steinmann s pin, an incision of about one fifth of an inch should be made in the skin, as otherwise the tension of the skin around the metal causes pain and necrosis Steinmann s pins may be introduced by attaching a handle to the square end of the pin and then by a rotatory movement pushing it through the bone Alternatively the pin may be hammered in

For the introduction of a Kirschner wire a hand or electric drill is necessary but in either case owing to the flexibility of the wire a special attachment to the drill is necessary in order to keep the wire straight as it is introduced The powerful stirrup which is then attached to the wire must hold it under considerable tension so that it will not bend when traction is made on it A number of ingenious straining devices have been invented for this their common principle is to compress the two arms of the stirrup together prior to tightening the nuts which hold the wire the strainer is then removed and the spring of the stirrup is sufficient to hold the wire under tension so that it does not bend when pulled upon

Each of the methods of applying skeletal traction has its own advocates A Steinmann s pin has the great advantage of having a rigid immovable hold on the bone The simplicity of the pin, added to its reliability appears to the writers as preferable to the special apparatus required for a Kirschner wire added to the risk of its breaking The difference in the size of the hole in the two cases seems of little importance and provided proper aseptic precautions are observed the scar in the skin and subcutaneous tissues is little different whether a pin or a wire has been used.

*Comparison of Skin and Skeletal Traction* Skin traction has the two advantages that there is no danger of introducing sepsis into the bone and that it can be applied more readily and with less preliminary preparation than skeletal traction In children where the required weight is small and in those adult cases where the degree of pull necessary is not great, skin traction is to be preferred But with adults in whom a weight of over twelve pounds may be necessary skin traction sometimes leads to slipping of the adhesive plaster or glue

and to the formation of blisters and septic ulcers which make any subsequent use of skeletal traction unsafe In all such cases a direct pull on the bone is to be preferred and should be obtained from the outset Some of the chief advantages of skeletal traction over skin traction are that by it a stronger pull may be obtained, there is better control of the distal fragment of the fractured bone, in most cases it is less painful and actually more comfortable for the patient and there is greater freedom of the limb The main objections to skeletal traction are that it requires special apparatus, there is the risk of sepsis if the pin is introduced near a joint quite a minor degree of infection may irritate the adjacent synovial membrane causing extra stiffness, and it is easier to produce excessive traction separation of the bony surfaces and delayed or non union Where fractures are being constantly treated the difficulty of having special apparatus should not occur and it is only where the treatment of a fracture is an occasional incident that the difficulty of having the necessary pins and wires at hand arises Sepsis around a pin or wire used for traction is a rarity but when it does occur it is not usually serious and often only takes the form of a local cellulitis of the skin and subcutaneous tissues it subsides quickly after the pin is removed However osteomyelitis and even suppurative arthritis have been recorded following the careless use of skeletal traction Another objection which has been advanced against the use of skeletal traction is that a pin or wire if put through a bone just proximal to a joint may encroach upon the latter as it slowly cuts its way through the cancellous bone actually this is rarely seen and it is more likely to occur with a wire than with a pin and with a wire which is a little slack rather than with one which is taut Only in exceptional circumstances should skeletal traction be used in a child

Briefly then it may be said that skin traction should be used in children and where only a small weight is necessary in an adult and where there is evidence of sepsis present either locally or in the form of an active or recent septicæmia Skeletal traction should be used where a strong pull in an

adult is required and where there is no evidence of local or general sepsis

(3) Reduction by Operation From time to time opinion has varied with regard to the advisability of open operation Arbuthnot Lane in this country led the school of surgeons who advocated exact anatomical reduction of every fracture They performed an open operation whenever necessary and fixed the fragments with screws and a metal plate Since the time of Lane s work on fractures the pendulum has swung back towards closed reduction The attraction of open reduction is that it presents an easy way to obtain perfect anatomical replacement of the fragments and the anxieties attendant in the possibility of redisplacement can be avoided by securely plating or screwing the fragments together Of recent years the procedure has been rendered still more attractive by the introduction of plates made of metallic alloys which are non-electrolytic in the tissues and of screws which besides being made of the same alloy are long enough to go right through the bone and obtain a firm grip on the opposite cortex

But the penalties of operation remain the same A closed fracture is being deliberately converted into an open one with all the disastrous risks of infection further damage is being inflicted on the soft tissues particularly the muscles and this means more adhesions more scarring, and more stiffness if the fracture is plated with slight distraction or if the bone on either side of the fracture line becomes absorbed a little as it sometimes does a gap is left and union is sure to be delayed while the gap is slowly filled by bone Finally the patient is conscious of the presence of a foreign body and while some possess their plates proudly others eventually will demand their removal for real or imaginary symptoms

Open reduction of a fracture is indicated—

(1) Where manual reduction or traction has failed to produce a satisfactory position Usually this is either because the fracture reaches expert hands too late for correction of a severe malposition or because some interposed soft tissue or bone

fragment prevents proper apposition of the fractured surfaces

(2) When it proves impossible to hold the fracture securely in a proper position Reduction may perhaps have been comparatively easy but as soon as the pressure or traction of the surgeon's hands is relaxed and the splint is applied displacement recurs Such lesions as oblique fractures of the shaft of the tibia or transverse fractures of the tibia and fibula or of the radius and ulna at the same levels may all behave in this way

(3) In certain fractures, experience has shown that better results are obtained by resort to operation without trying other methods of reduction These are fractures of the olecranon process of the ulna and fracture of the patella where there is usually wide separation of the fragments Fracture of the shafts of the femur and tibia and fibula in the same limb and similarly fracture of the humerus radius and ulna where the fractures of the femur or of the humerus may be very difficult to reduce and control until the tibia or the radius and ulna have been plated. Fracture-dislocation of the dorsal or lumbar area of the spine with interlocking of the articular processes can only be reduced by exposing and removing the interlocked elements

This does not exhaust the list of fractures in which operation may be the best procedure For instance a fracture of the neck of the femur although it can be reduced easily enough by manipulation cannot be securely immobilised except by the insertion of a Smith Petersen nail. Comminuted fractures of the head of the radius do better after resection and certain fractures of the os calcis are well treated by early arthrodesis of the sub astragaloid and mid tarsal joints But these are not strictly speaking operations for reduction of the fracture

There is sometimes a doubt as to the optimum time for performing open reduction Fairbank* has said that there

* Fairbank, *Brit Med. Journ* Oct 194*

should be the earliest possible operation compatible with (1) the condition of the patient, (2) adequate preparation of the skin and (3) the provision of good facilities and expert surgical skill Bearing this advice in mind it is unusual that operation can be carried out less than two days after the fracture has occurred but there should be no unnecessary delay after this After forty-eight hours there is an increasing risk of disturbance to the biochemical processes associated with healing of the fracture After ten days the jagged sharp bone ends are becoming rounded off and covered with organising clot so that an accurate interlocking fit is difficult Later still the soft tissues surrounding the fracture will have become contracted so that it may be impossible to overcome displacement of the bone ends

When operation is done early and successfully by an expert, union of the fracture will not be delayed and the ultimate result will be satisfactory although not as good as if the fracture had been reduced by hand at the first attempt However there is no greater disaster in fracture treatment than an unsuccessful open reduction

## Immobilisation

After reduction the fracture must be protected by some form of splint until it has united. Splinting must be continuous but the use of the phrase rigid immobilisation may give rise to confusion of thought In the first place immobilisation of the healing fracture does not for a moment imply immobilisation of the whole limb it has long been a principle that the joint above and the joint below the fracture should be splinted and modern technique still adopts this fundamental in treatment but the splinting of to-day is designed to allow the fullest possible use of the limb and the patient is encouraged to move joints which are not included in the splint and to contract muscles acting across those joints which have perforce to be immobilised

Then it is has been suggested that unless a fracture is rigidly immobilised union will not occur but it is a common experience that many fractures unite perfectly

satisfactorily and rapidly when they have not been immobilised in the true sense of the word at all Occasionally a fracture is not diagnosed until after an X ray shows that it has already joined up fractures in the limbs of small children and of animals will unite when it is obvious that splinting has been quite ineffective, rigid immobilisation of the ribs or of the clavicle is impossible by the ordinary methods of treatment yet fractures of these bones become firmly united with great regularity On the other hand we know that fractures of the carpal scaphoid and of the neck of the femur will only unite if immobilisation is rigid and continuous and that most fractures of the long bones of the limbs will unite far more certainly and quickly if the fracture is splinted by a well fitting plaster of Paris cast which does not allow movement at the site of fracture

To understand this apparently varied state of affairs we must remember that one of the principal features of what has been called the fracture healing process is the spread of granulation tissue across the interval between the broken ends of bone (see Chapter V) If these strands of tissue are ruptured it seems reasonable to suppose that the healing or union of the fracture will be interrupted A certain amount of movement between the bone ends may not break up this delicate tissue but strains, particularly of a bending, shearing or rotating nature, probably will so that the process must begin all over again and union will be delayed The strength of the granulation tissue which has formed, its power of regeneration and the amount and type of stress to which the bone is subjected are all capable of considerable variation furthermore, the arrangement of muscles around the bone and their contraction in spasm may have a very profound effect in preventing more than a very small amount of movement at the fracture All these variable factors probably account for an apparent discrepancy in the behaviour of different bones in relation to immobilisation

It follows that when in the treatment of fractures we refer to immobilisation, what we mean is protection from strain ' and this phrase gives a much clearer picture of our real aims

The splint has two other important functions besides this one of protection Apart altogether from its use in first aid after the fracture has been reduced the splint prevents movement of the bone ends on each other and in the early stages when every such movement is painful brings comfort to the patient The splint also serves to prevent redisplacement after the fracture has been reduced

Until about twenty years ago great ingenuity was displayed by surgeons in devising many different types of splint Recently improvements in the technique of reductions and in the application of plaster introduced by Böhler of Vienna have enabled us to discard most complicated pieces of apparatus in favour of the plaster of Paris cast *All splints used nowadays can be grouped quite simply* into—

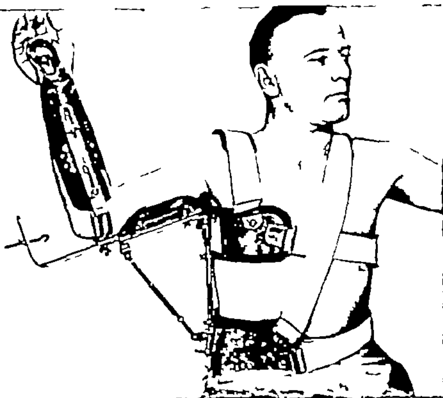
(1) Slings bandages and strapping
(2) Special types of splint
(3) Internal fixation by plates and screws
(4) Plaster of Paris casts

**(1) Slings Bandages and Strapping** There are some fractures in which there is no risk of redisplacement or in which displacement of the fragments is of no consequence, in these the protection from strain offered by slings bandages or strapping appears to be quite enough to ensure union Examples are fractures of the clavicle and ribs fractures in the region of the shoulder and elbow joint and many fractures of the metacarpals and phalanges of fingers or toes

**(2) Special Types of Splints** Although various commercial patterns exist and modifications have at times been introduced by different surgeons the special splints in common use to-day are very few in number

*The shoulder abduction splint* (Fig 5) often called the aeroplane splint may be used simply to elevate a swollen limb or in those injuries of the shoulder region in which paralysis of the deltoid muscle is a complication its use will be further described under different fractures later in the text but certain points about the splint may be emphasised now Although a splint which will support the arm in

right-angled abduction is often used, the more complicated apparatus illustrated, in which the angle of abduction and the degree of rotation can be altered, is more generally useful The rotating adjustment is particularly important because there are several injuries of the shoulder region which are better treated with the humerus in a position of



[By courtesy of the London Splint Co.

FIG 5.—Shoulder abduction splint.

external rotation as well as abduction The splint must be carefully fitted and for fracture work when the splint cannot be made for the individual patient this requires skilful padding In one of these splints the patient is invariably far more comfortable when up and about than in bed

*The wire finger splint* (Fig 6) is malleable and is always used in conjunction with a plaster cast The use of the

splint is described under the sections dealing with fractures of the metacarpals and phalanges

*Thomas splint*, or "bed knee splint" is used very widely in the first-aid treatment of fractures of the lower limb and is the most widely accepted splint for the treatment of fractures of the shaft of the femur It is used in association with traction on the leg which can be applied by means either of strapping or a metal pin or wire methods which



FIG 6 Wire finger splint The splint is made of malleable wire *It is shown unpadded and padded.*

have already been described when the reduction of fractures was discussed The pull may be exerted either by "fixed traction" (Fig 7) or by "weight and pulley traction" When the latter method is used the splint is usually suspended from an overhead beam—a "Balkan beam" This modification of weight and pulley traction is known as "balanced traction" (Fig 8) A useful accessory to the Thomas splint is a hinged support allowing flexion of the knee

*Braun's leg splint* (Fig 9) was evolved in Böhler's

clinic in Vienna and is most useful for the elevation and support of the limb in fractures of the tibia, fracture

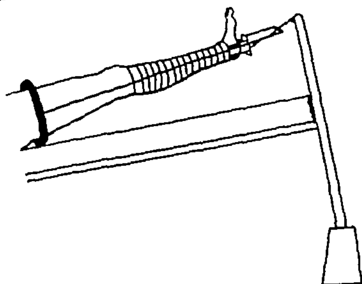


Fig 7 —Thomas splint or "bed knee splint."

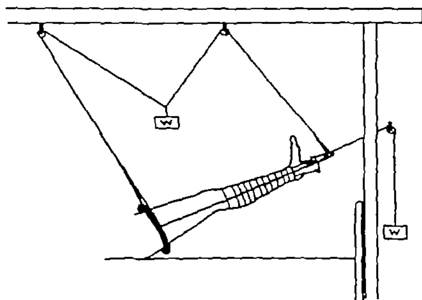



Fig 8 —Thomas splint or "bed knee splint Balanced reaction.

dislocation of the ankle and fractures of the tarsal bones The apparatus is a support rather than an actual splint because it is used when the limb is already in plaster but

if necessary traction can be exerted through weights over the pulley attached to the frame There are a few simple rules which should be observed if the splint is to be most effective fracture boards should be used the frame should be fastened to the end of the bed the patient must be taught to keep his knee over the bend in the splint, if traction is being used the ends of the pin or wire must be kept clear of the side bars the foot of the bed must be

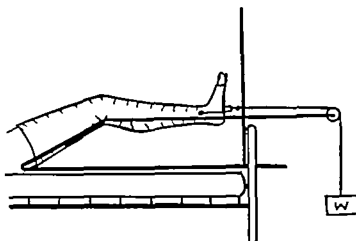



FIG 9 —Braun's leg splint

elevated and the weight allowed to swing freely clear of the end of the bed

(3) INTERNAL FIXATION The indications for open operation in the reduction of fractures have already been discussed Some fractures even when exposed and reduced by operation, will not remain in position and these fractures need some method of direct fixation The internal splint must be absolutely secure at the time and must remain secure For this reason such things as catgut loops wires and Parham s bands have been discarded because all may work loose after a short time even if secure at the end of operation

After accurate anatomical reduction of the fracture by operation, really secure apposition can be maintained by metal screws alone by metal plates fastened to the bone by screws or by a cortical graft from the same or another bone held in position by screws

A description of the technique and indications for use of the various forms of internal splint is not within the scope of this book, the matter is one for the expert and the whole question of the desirability of internal splinting and what form it should take is still the subject of a good deal of argument

(4) PLASTER OF PARIS The physical properties of calcium sulphate allow it to be used as a most effective splint in the treatment of fractures There has been a tendency to refer to the plaster treatment of fractures,' but the use of this sort of phrase indicates a lack of understanding of the simple nature of the principle of splinting which can be exerted by plaster of Paris in such a convenient effective and comfortable manner The substance is used in the form of bandages made from Book muslin or ' Crinoline muslin impregnated with finely powdered plaster The bandage can be made either by hand or by a mechanical process Good hand made bandages are very satisfactory in use but they do have certain disadvantages which are not shared by the best modern commercial product Hand made bandages are not consistent in texture so that there is a good deal of variation in the quantity of bandage required to make any given thickness of splint the plaster tends to fall out of the bandage during storage and certainly shakes out during carriage finally although well made bandages are satisfactory they are difficult to make except by an experienced worker who possesses the necessary touch. Badly made plaster bandages are useless and may be harmful to the patient The best commercial product on the other hand is consistent in structure keeps well under ordinary conditions and does not lose plaster by shaking neither is it at all certain that it is more expensive in use

In the treatment of fractures the plaster of Paris bandage is used to make either a complete cast of the limb or in the form of a gutter splint

Plaster of Paris is prepared from solid crystalline gypsum by heating at 120 F three molecules of water are given up in the reaction

$$2(CaSo_4\ 2H_2O) \rightleftarrows (CaSo_4)_2,\ H_2O + 3H_2O$$



and powdered anhydrous calcium sulphate remains When water is added to the powder it reverts to the crystalline form and it is the formation and firm interlocking of these crystals which constitutes the "setting" of a plaster cast this setting phase or 'critical point" can be recognised by the plaster becoming rich and creamy and losing its wet glistening appearance During this time when the substance is passing from its fluid to its solid state any disturbance of the setting plaster should be avoided because movement and interference at this stage will lead to the formation of long thin crystals loosely woven together whereas if disturbance is avoided the crystals will be short stout and closely knit and a strong durable plaster cast will result Ideally therefore the application of all the plaster bandages to make the cast should be completed before the critical point is reached and thereafter the cast should be allowed to set without movement, heavy moulding, or rubbing Setting time can be modified by the temperature of water It has been found experimentally that the setting time of a plaster bandage soaked in water at 40° F is three times as long as when water at 125 F is used Cold water is usually uncomfortable for the patient and of course could not be used if there is any danger of shock in practice a tempera ture of 70° F is usual

When the bandage is soaked it takes up far more water than is required to convert the anhydrous gypsum to the hydrated form and subsequent drying of the cast may take some time Drying is aided by the circulation of warm dry air but is retarded by covering with wearing apparel bed clothes and sweating under a heat cradle A cast does not attain its maximum strength until complete crystallisation and complete drying has occurred

Good technique in the preparation of bandages and the application of plaster casts and gutter splints can only be achieved by constant practice and experience Written descriptions are of little value but there are some points in the proper use of the bandage which should be emphasised.

Soaking the Bandage The water container should be wide mouthed and at least twelve inches deep the domestic

slop pail or a bucket is on the whole preferable to a basin The vessel should be three-quarters full of water Each bandage is picked up by the two hands holding the ends of the roll, placed horizontally gently in the water and allowed to sink to the bottom Two or three bandages may be placed in the pail at a time The bandage is allowed to soak for about a minute and is then removed again by the extremities of the roll and is gently squeezed to remove any gross excess of water The loose end is found and separated and the bandage handed to the operator The water in the bucket should be changed after at the most twelve bandages have been soaked two buckets are useful

APPLYING THE BANDAGE The bandage must always be laid on not drawn on a well fitting plaster cast is achieved by gentle moulding round the prominences of the limbs and never by pulling the bandage tight The turns of bandage should be applied in a regular manner up and down the whole length of the cast and should overlap by about one third of their width, by applying the bandage in this way it is possible to count the number of layers applied this produces a cast of even thickness which is more efficient than the cast which has been applied in a segmental manner If the operator will realise that he is making a cast and not simply applying a bandage he will go far towards becoming a successful technician.

MANUFACTURE OF SLABS The plaster slab ' or folder is used extensively in fracture work either as a foundation for the cast or as reinforcement in potentially weak places The essential point in the non padded" plaster technique introduced by Böhler is that the plaster bandages are invariably applied over a plaster slab which has been moulded accurately to the contours of the limb and always covers over half its circumference To prepare these slabs the bandage is taken out of water and rolled out to the required length on a table—a slab of any desired thickness may be made With the usual commercial bandage six layers is sufficient for most purposes if a cast is being used although if the slab is intended for use as a gutter splint twice this thickness may well be necessary

In making a slab it is important to work quickly so that it may be applied before the plaster has begun to set that is whilst it is still perfectly supple

SETTING OF THE CAST Probably enough has been said about the physical properties of plaster to make it quite obvious that the cast must be applied rapidly and gently and that all movement must as far as possible be avoided once the critical point has been reached when the cast begins to set The deep layers of a large cast will usually begin to set before the cast is finished—any movement may produce cracks and ridges in these layers which are not visible on the surface of the cast at all ridges in the plaster produced in this way are a most common cause of pressure sores

*PADDED AND UNPADDED CASTS* Plaster casts may be padded or applied directly to the skin without padding Many substances have been used for padding such as stockinette wool flannel and felt A most convenient form of padding is dressmakers wool which is glazed on one side so that it can be cut into strips and rolled up it is then easily and quickly put on. The advantages which have been claimed for the padded plaster cast are that it is more comfortable fits better and that it is not so likely to chafe the skin and cause ulceration Amongst others Böhler has emphasised the advantages of using an unpadded plaster cast in which a plaster slab is moulded on to the limb and secured with plaster bandages applied directly next to the skin Experience with this method shows that the claim of comfort of better fitting and safety which have been advanced for the padded cast apply with even greater emphasis to the unpadded cast It is true that to put on an unpadded plaster cast well and safely requires some practice but an evenly fitting and a well made unpadded cast is as comfortable and usually more so than one in which there is padding because with the latter the wool often gets a little displaced and causes discomfort from uneven pressure For the same reason because the plaster fits evenly it does not rub the skin and sore places are not so likely to occur The chief advantage of the unpadded plaster cast is that because it fits closely and therefore supports the soft tissues

of the limb, œdema does not occur This allows normal blood and lymph circulation to continue and the whole limb remains in a healthy condition Because the unpadded plaster fits so accurately the limb may be used actively from the beginning without fear of displacement of the fragments, and because of this active use the tone of the muscles is maintained For these two reasons—even support of the limb and early active use—the unpadded

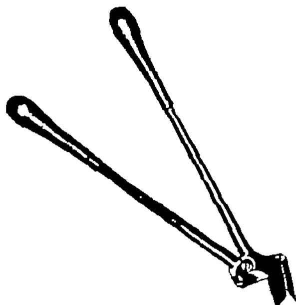


FIG 10—Plaster shears of the Lorenz type

plaster cast helps in bringing about a much quicker recovery of normal function

Plaster casts should not be split down one side except when excessive swelling is likely to occur causing pressure on the main vessels and thereby imperilling the circulation In such cases when the plaster is set but before it is quite hard it is cut down on each side with a sharp knife If the plaster then becomes too tight the front half can be removed or loosened but the limb remains supported in the back half so that the position of the fractured bones is undisturbed

A half plaster cast is sometimes used to rest the limb when there is an open wound which requires attention It

is best made by dividing a complete cast down each side and removing the anterior half

*The removal of a plaster cast* is usually a matter of great difficulty to the inexperienced but more often than not the cast which is difficult to remove is one which has been badly applied uneven thickness and bands over bony prominences presenting the main obstacles Several authors have suggested various gadgets for aiding the removal of casts but nothing can replace adequate experience aided by a pair of plaster shears of the Lorenz type (Fig 10)

The patient s limb must be properly supported and securely held at each end of the cast—particularly so if the fracture may not be firmly united In using the shears the one hand is used for steadying and pushing on the blade while cutting action is maintained with the other Bites of quarter to half inch are quite sufficient , attempts to divide larger fragments at a time will exhaust the operator alarm the patient and sometimes break the shears Bony prominences and open wounds should be avoided as far as possible if a wound is present the shears must be properly sterilised before using them to remove the plaster

COMPLICATIONS OF PLASTER CASTS (1) SORES Plaster sores are ulcers the result of destruction of the skin and subsequent infection The injury to the skin may be caused by friction or by pressure of the plaster over a localised area It is important to distinguish between these two the first occurs when a plaster is too loose and occurs as readily with the padded as with the unpadded plaster cast A plaster sore from pressure is more likely to occur with an unpadded plaster but should never occur if a careful technique is used There should be accurate moulding of the plaster to the exact contour of the limb and any movement of the plaster on the limb while it is setting should be avoided Movement causes a kink in the plaster so that when the plaster sets a hard ridge is left which pressing on the skin, is very likely to cause a pressure sore Sometimes when a plaster is changed, fragments of hard dry plaster from the previous cast are left adhering to the skin The pressure of a new cast on these lumps may cause necrosis of the skin and

a plaster sore If the setting plaster is gripped by an inexperienced assistant his thumb or fingers will cause indentations in the plaster which may quite easily be deep enough to produce a sore

(2) SWELLING More often than not, once a fracture has been reduced and a plaster cast applied no further swelling of the limb will occur and what swelling there is will immediately begin to diminish Sometimes however a cast will become too tight from further swelling of the limb either because reactionary œdema has increased in spite of the supporting plaster or because the superficial veins and lymphatics in the limb are constricted by a badly applied cast Swelling of the limb and tightness of the cast will usually clear up with elevation of the limb and active movements of the fingers or toes and are not in themselves of serious significance but if there is evidence of obstruction to the circulation such as increasing pain paræsthesiæ, coldness and cyanosis of the limb anæsthesia or paralysis then the obstruction must be relieved without delay by splitting the cast throughout its length and on both sides.

The technique used in the application of individual casts can only be mastered by constant practice but it is encouraging to remember that comparatively few types of cast are used in treatment of fractures They are—

(1) The head and neck cast or Minerva jacket
(2) The spinal plaster or jacket
(3) The thoraco brachial cast
(4) The single or double hip spica
(5) The complete leg plaster with and without a walking attachment
(6) The leg cylinder for immobilisation of the knee
(7) The below knee cast with or without walking heel
(8) The horseshoe cast for fractures of the humerus
(9) The complete arm plaster
(10) The forearm and wrist cast
(11) The scaphoid plaster
(12) The Böhler finger splint and cast

These casts do not vary in their shape for individual fractures All that need be decided is which particular cast

is best made by dividing a complete cast down each side and removing the anterior half

*The removal of a plaster cast* is usually a matter of great difficulty to the inexperienced but more often than not the cast which is difficult to remove is one which has been badly applied uneven thickness and bands over bony prominences presenting the main obstacles Several authors have suggested various gadgets for aiding the removal of casts, but nothing can replace adequate experience aided by a pair of plaster shears of the Lorenz type (Fig 10)

The patient's limb must be properly supported and securely held at each end of the cast—particularly so if the fracture may not be firmly united In using the shears the one hand is used for steadying and pushing on the blade while cutting action is maintained with the other Bites of quarter to half inch are quite sufficient attempts to divide larger fragments at a time will exhaust the operator alarm the patient and sometimes break the shears Bony prominences and open wounds should be avoided as far as possible if a wound is present the shears must be properly sterilised before using them to remove the plaster

COMPLICATIONS OF PLASTER CASTS (i) SORES Plaster sores are ulcers the result of destruction of the skin and subsequent infection The injury to the skin may be caused by friction or by pressure of the plaster over a localised area It is important to distinguish between these two the first occurs when a plaster is too loose and occurs as readily with the padded as with the unpadded plaster cast A plaster sore from pressure is more likely to occur with an unpadded plaster but should never occur if a careful technique is used. There should be accurate moulding of the plaster to the exact contour of the limb and any movement of the plaster on the limb while it is setting should be avoided Movement causes a kink in the plaster so that when the plaster sets a hard ridge is left which pressing on the skin is very likely to cause a pressure sore Sometimes when a plaster is changed fragments of hard dry plaster from the previous cast are left adhering to the skin. The pressure of a new cast on these lumps may cause necrosis of the skin and

muscles to become adherent to bone and fascia, and tendons to be fixed in their sheaths

EFFECTS OF IMMOBILISATION Joints which are not moved become stiff if the joint is uninjured this stiffness will be temporary and can be rapidly overcome by the patient s active efforts However if the joints have been irritated by direct injury or by infection, the range of movement may become permanently limited and this limitation will be more intense depending on the degree of injury and the length of time during which the joint has had to be immobilised Exactly the same considerations hold good for muscles which are immobilised

EFFECTS OF DISUSE Although some of the results of disuse are the same as those of immobilisation, there is in addition an effect on the nerve path between brain and muscle which prevents the patient from initiating voluntary contractions in muscles and joints though they may be quite unharmed, as well as in those which have been involved in the injury This is a matter of common experience but no explanation has been made why a period of disuse should produce this effect It is best imagined as a ' lack of practice in the passage of impulses between the cerebral cortex and the joints and muscles

If loss of function is to be overcome, initial and late effects of local injury the effects of immobilisation and the effects of disuse must all be countered by proper treatment

Recovery of function will depend largely on the patient s own active efforts so that it is important that he should regain confidence in his limb and that his morale should be restored as soon as possible after the injury Prompt and effective treatment of the fracture will relieve pain and remove that feeling of instability which is inherent in a broken bone The fracture should be reduced at one sitting otherwise the patient is subject to demoralising suspicions of failure on the part of his doctor and this means that proper facilities for anaesthetic and X ray should be avail able Once the fracture has been set and a plaster applied the limb should be comfortable within a matter of hours Comfort is essential if the patient is to be persuaded to start

is to be used and it is then applied to the limb For example the below knee walking plaster is no different whether it is used for treatment of a fracture-dislocation of the ankle or a fracture of the calcaneum.

### Restoration of Function

It has been well said that a fracture is in the first place injury to an individual in the second a severe injury to the soft tissue of a limb and in the last a broken bone This does not belittle the importance of proper treatment of the fracture itself but concentrates attention on other features of the injury

If there is one direction more than another in which fracture treatment has advanced of recent years it is in the widespread recognition of how absolutely necessary it is to pay more attention to the injured person and to the effect of a fracture on the soft tissues if the best function is to be restored to an injured limb in the shortest possible time If treatment is to be wholly successful, measures to regain the use of the limb—not simply union of the fracture—must be taken very early The patient must be convinced that recovery will depend largely on his own active efforts to regain control of the limb movement in the joints and power in his muscles and he must be persuaded to make these efforts towards recovery his task throughout the day and not to rely on an occasional or even a daily visit to some massage or physiotherapy department

In a short chapter no attempt will be made to do more than explain the principles of restoration of function or rehabilitation as it has come to be called

Loss of function is one of the classical signs of fracture This is due in the first place to the immediate effects of a local injury to bone joints and soft tissues Later healing of the injury itself a period of immobilisation and disuse of the limb all produce effects which prolong the disablement and may result in some permanent loss of function.

Late Effect of Local Injury Quite obviously during healing scars and adhesions will form which may cause

movements go beyond the joints themselves Muscles and tendons contract and move dispersing excess hæmatoma and œdema fluid which may have collected between muscles and fascia and in the tendon sheaths. The circulation of blood and lymph throughout the limb is assisted

At a later stage when the limb is free from splints, simple exercises are used to restore movement to those joints which have been immobilised

(2) CONTRACTION OF MUSCLES AGAINST INCREASING RESISTANCE. *Although active movements of joints* will help in preventing stiffness something must be done in addition to keep up the strength of the *muscles* *While the limb is still splinted,* gradually increasing confidence will enable the patient to increase the load on many of his muscles by using his limb more and on increasingly difficult tasks Sometimes important muscles like the deltoid and biceps in the arm, or quadriceps extensors in the thigh, cannot be helped in this way because of splinting which fixes shoulder elbow or knee, in these cases the power of the muscles is preserved to a certain extent by static con tractions

Once the splint has been removed all sorts of methods can be devised for building up the muscles *by exercise against gradually increasing resistance*

(3) ACTIVE USE OF THE WHOLE LIMB AS AN INDIVIDUAL UNIT AND IN CONJUNCTION WITH THE REST OF THE BODY Using the limb involves active movement of the joints and contraction of the muscles, but in addition it particularly attacks that effect of injury and disuse which results in diminished cerebral control of the limb and restores the patient's confidence in his injured limb and in himself

In the practical treatment of fractures this technique is *applied during three phases* As soon as the limb is securely splinted and comfortable the patient receives instructions in simple exercises for those joints which are not immobilised

active contractions of his muscles and to use the limb If pain continues and particularly if the pain occurs on movement the splinting is at fault either the cast does not fit the limb correctly so that the ends of the broken bone are not being prevented from moving on each other or there is a point of pressure—a ridge or indentation or the cast is too tight and is obstructing the circulation to a greater or less degree These defects must be corrected without any delay

To enlist the patient s co-operation in his further treatment the nature of his injury should be simply explained to him, and the proposed course and duration of treatment outlined. He should be given some estimate of the degree of recovery to be expected and if it is obvious in the early stages of treatment that there must be some permanent disability or incapacity he should be informed of this if he is to be spared disappointment

Many patients with injuries are beset with difficulties of an economic or social nature and it is advisable that they should be settled or anyhow tackled in the light of the explanation which has already been given to him about his disability Welfare workers almoners industrial medical officers insurance companies employers trade unions and solicitors all play varying parts in this and there is a growing realisation that such problems must be examined and where possible solved early in treatment rather than at the end It is of course not the job of the doctor to settle these difficulties but it is very much his duty to make certain that questions of this sort are being faced early and in the right manner

Once the limb is comfortable and while the background of social and economic problems is being cleared treatment can be directed towards the restoration of local function The technique is essentially simple and consists in —

(1) ACTIVE MOVEMENT OF THE JOINTS At first only those joints which are not included in plaster or splints can be moved. Active movement should be carried out through the full range at each joint and it is important to see that this object is not prevented by badly fitting splints The effects of active

movements go beyond the joints themselves Muscles and tendons contract and move dispersing excess hæmatoma and œdema fluid which may have collected between muscles and fascia and in the tendon sheaths. The circulation of blood and lymph throughout the limb is assisted

At a later stage when the limb is free from splints, simple exercises are used to restore movement to those joints which have been immobilised

(2) CONTRACTION OF MUSCLES AGAINST INCREASING RESISTANCE. Although active movements of joints will help in preventing stiffness something must be done in addition to keep up the strength of the muscles While the limb is still splinted gradually increasing confidence will enable the patient to increase the load on many of his muscles by using his limb more and on increasingly difficult tasks Sometimes important muscles like the deltoid and biceps in the arm, or quadriceps extensors in the thigh, cannot be helped in this way because of splinting which fixes shoulder, elbow or knee in these cases the power of the muscles is preserved to a certain extent by static contractions

Once the splint has been removed all sorts of methods can be devised for building up the muscles by exercise against gradually increasing resistance

(3) ACTIVE USE OF THE WHOLE LIMB AS AN INDIVIDUAL UNIT AND IN CONJUNCTION WITH THE REST OF THE BODY Using the limb involves active movement of the joints and contraction of the muscles, but in addition it particularly attacks that effect of injury and disuse which results in diminished cerebral control of the limb and restores the patient s confidence in his injured limb and in himself

In the practical treatment of fractures this technique is applied during three phases As soon as the limb is securely splinted and comfortable the patient receives instructions in simple exercises for those joints which are not immobilised

and is shown how to carry out static contraction for the principal muscles It is explained to him that if the most benefit is to be obtained from them exercises should be carried out at regular intervals throughout the day—five minutes in every hour is the ideal Contraction of the muscles should be slow, should be sustained at the peak and should be followed by complete relaxation the sequence—contraction—hold—relax—must be carried out rhythmically The exercises and movements should not be painful once any slight initial stiffness has cleared up and he should report the fact if pain continues or recurs

In the second phase while the fracture is uniting protected by a splint the patient is encouraged to persevere with regular exercises and active movements and is persuaded to use the limb more and more within the limits of the splint He is shown how to use his fingers and how to walk in plaster If circumstances allow and the conditions of employment are suitable he is encouraged to return to work. If his occupation is a strenuous one he will probably not be able to return to it in plaster but even at this stage in treatment special attention must be paid to restoring and maintaining the strength of the muscles with a view to his ultimate return to heavy work It is this type of patient for whom the rehabilitation centre is particularly required there he can work all day for his own recovery

In the final phase of treatment when the fracture has united and all splinting is discarded active movements for those joints which have become stiff in plaster can be instituted and exercises to restore power to muscles which have not been acting through their full range are continued. In addition proper co-ordination between limb and body is regained by general physical exercises games and occupational therapy

The technique of restoration of function is the same whether the patient is in or out of hospital In hospital, rehabilitation is always easier and more successful if patients with fractures are segregated in one ward There they can learn together the importance of making their own efforts towards recovery and the necessity for performing

their muscle exercises and joint movements at regular intervals throughout the day As out patients, success will depend on the care with which the preliminary instruction of the patient has been carried out, and on careful supervision at regular intervals in the fracture clinic

Patients with serious fractures and those who have to return to heavy work are best treated in a "rehabilitation centre" The centre need not be residential but the essential points are that the patient should be there for the whole day and every day and that facilities such as gymnasium, swimming bath recreation rooms and playing fields should be available for exercises and activities designed to restore him as soon as possible to his best working capacity

Nicoll * has summarised the principles of therapeutic exercises as follows —

(1) They must be both specific (focal) and general
(2) They must be administered with due regard to dosage
(3) They must be rhythmic in regard to contraction and relaxation
(4) They must be progressive in range power and time
(5) They must be variable in form, the chief forms being medical gymnastics occupational therapy and recreational therapy

If the surgeon wishes to secure the best result in restoration of function he cannot afford to rely entirely on a physiotherapist or physical training instructor for rehabilitation of his patient It is true that instruction in muscle exercises and joint movements and the supervision of class exercises games and occupational therapy are best conducted by trained medical auxiliaries but the surgeon must make certain that his patient understands why he is doing exercises and why it is so important for him to use the injured limb He should make opportunities to watch the patient carry out his rehabilitation programme and must be readily available to investigate any complaint that a movement or exercise is painful or is causing deterioration rather than improvement When treatment is being undertaken as an out patient perhaps the most difficult points to drive home

* Nicholl E. A. (1943) *Brit. Med J* 1, 747

to the patient are that exercises and movements must be performed regularly throughout the day every day and not just once a day or three times a week in the physiotherapy department and that the very important principles of dosage and progression in activity must not be upset by carrying suitcases and heavy coal buckets by standing in cinema queues or by unauthorised games of football and country rambles Control over private activities of this sort can only be exerted by the surgeon himself and then only if he has gained the trust and confidence of his patient by his personal care and interest throughout all the stages of treatment

CHAPTER IV

# COMPOUND FRACTURES

A FRACTURE is open or compound when there is in addition a wound of the soft tissues opening to the surface and providing a direct communication between the bone and the outside air The wound usually involves the skin of a limb and in everyday life the leg is most often involved but nearly every fracture of the jaw is an open fracture with a wound into the mouth through the muco periosteum of the alveolus

Though the injury to bone may be the same whether a fracture is closed or open the problems of treatment are different because of the greater liability to shock in an open fracture and the presence of a wound

Of the possible complications of the wound infection is outstanding The probability of an infection depends on the amount of damage to the soft tissues and the degree of soiling of the wound particularly the depth to which contaminated material has been forced Although damage to and actual loss of skin is of significance it is the destruction and local death of muscle which is the most dangerous factor in a compound fracture because of the risk of infection with anaerobic bacilli and subsequent gas *gangrene*

The wound may be caused after the fracture by the protrusion through the soft tissue and skin of a sharp fragment of bone In this case the wound is usually small and the damage to the soft tissues is not extensive On the other hand if wound and fracture are produced by the same outside force for example the wheel of a road vehicle or a fragment of bomb the laceration and destruction of skin fascia and muscle may be very considerable the bone is likely to be comminuted and earth clothing and fragments of metal may be ground or driven deeply into the wound

In the two types of open fracture the risks of shock and infection are far greater in the second than in the first

Treatment of the wound with the object of preventing infection is of first importance because of the danger to life and because if the bone itself becomes infected recovery of function will be long delayed.

The treatment of an open fracture consists in —

(1) First aid
(2) Treatment of shock
(3) Transfer of patient as soon as possible to a place where expert treatment of the wound can be undertaken
(4) Surgical treatment of the wound.
(5) Support to the tissues rest for the limb and immobilisation of the fracture by means of a properly applied plaster cast
(6) The prophylactic use of penicillin.

**First Aid** Severe hæmorrhage must be arrested but a tourniquet should be avoided if possible The wound is best left alone with the clothing not removed unless there is likely to be considerable delay in getting the patient to hospital The fracture must be splinted before the patient is moved to prevent further local damage and to minimise pain and shock An injection of morphia will usually be advisable and the patient must be kept warm, reassured and at rest

**Treatment of Shock** The first-aid measures outlined above are valuable in the prevention or postponement of shock but once the syndrome has developed there is no substitute for plasma or whole blood transfusion in its treatment This is not the place for an account of the complexities of shock nor for a description of the technique for resuscitation

**Transfer of the Patient** To postpone transfer of the patient to a surgical centre in order to allow him to recover from shock is only justifiable if transfusion can be carried out during this wait If it cannot, no amount of rest warmth or elevation of the foot of the bed is a good enough substitute and the transfer should be arranged without

delay Furthermore, it is well recognised that the value of proper surgical treatment of the wound in the prevention of infection diminishes as its application is delayed A somewhat arbitrary figure of six hours has been fixed beyond which surgical treatment should not be deferred

**Surgical Treatment of the Wound** The following points are worthy of attention —

Clean the skin thoroughly with soap and water or cetyl trimethyl ammonium bromide (C.T.A.B. or cetavlon)

Do not use a tourniquet unless hæmorrhage is severe

Enlarge the skin wound by incision in the long axis of the limb, allow the wound to open up easily by similar incision of the fascia Excise all dead tissue with a sharp knife or scissors, and clear out all dirt and debris It is unnecessary to remove the whole skin edge, but dead or excessively dirty tags should be cut off

Hopelessly damaged muscle is recognised by its altered colour failure to contract on stimulation by pinching, and failure to bleed all such "dead" tissue should be freely excised by incision in the long axis of the muscle. Do not divide muscles transversely.

Bone should not be removed unless it is extremely soiled or is completely separated from all connection with the soft tissues and therefore from its blood supply

Hæmorrhage must be carefully controlled but only large vessels need ligature other bleeding can be stopped by pressure

Nerves and tendons should be cleaned but not excised Never attempt primary suture of either although to make secondary repair easier it is a good practice to anchor the proximal and distal ends to their beds by one or two catgut sutures

The fracture may be manipulated into position, but no form of internal fixation must be used.

Powder containing penicillin or a mixture of one of the sulphonamides and penicillin should be applied to the recesses and sprinkled over all the surfaces of the wound

If there are deep pockets in the wound as for instance in the thigh in a compound fracture of the femur these

In the two types of open fracture the risks of shock and infection are far greater in the second than in the first

Treatment of the wound with the object of preventing infection is of first importance because of the danger to life and because if the bone itself becomes infected, recovery of function will be long delayed

The treatment of an open fracture consists in —

(1) First aid
(2) Treatment of shock
(3) Transfer of patient as soon as possible to a place where expert treatment of the wound can be undertaken
(4) Surgical treatment of the wound
(5) Support to the tissues rest for the limb and immobilisation of the fracture by means of a properly applied plaster cast
(6) The prophylactic use of penicillin

**First Aid** Severe hæmorrhage must be arrested but a tourniquet should be avoided if possible The wound is best left alone with the clothing not removed unless there is likely to be considerable delay in getting the patient to hospital The fracture must be splinted before the patient is moved to prevent further local damage and to minimise pain and shock. An injection of morphia will usually be advisable and the patient must be kept warm, reassured and at rest

**Treatment of Shock** The first aid measures outlined above are valuable in the prevention or postponement of shock, but once the syndrome has developed there is no substitute for plasma or whole blood transfusion in its treatment This is not the place for an account of the complexities of shock nor for a description of the technique for resuscitation

**Transfer of the Patient** To postpone transfer of the patient to a surgical centre in order to allow him to recover from shock is only justifiable if transfusion can be carried out during this wait If it cannot, no amount of rest warmth or elevation of the foot of the bed is a good enough substitute and the transfer should be arranged without

application of the cast Splitting the cast as a prophylactic measure tends to defeat its object and is not necessary provided the patient is under close observation so that the cast may be split at once if unexpected swelling causes embarrassment to the circulation On the whole the surgeon who is not experienced in dealing with fractures and in the use of plaster is well advised to apply a lightly padded cast and to split the cast throughout its length

In treating compound fractures of the tibia or the femur with shortening traction is necessary For fracture of the tibia a Steinmann's pin is inserted through the lower end of the shaft and after the plaster has been applied the leg is rested on a Braun's splint with weight traction

Pin traction through the tibia on a Thomas splint is probably the method of choice in the treatment of most compound fractures of the femur but if there has been much destruction of soft tissue it is unwise to dispense with the support of plaster

**Prophylactic Drugs** It must be emphasised that anti tetanic serum anti-gas gangrene serum penicillin and the sulphonamides are not magic substances and that their undoubted value in the treatment of compound fractures does nothing to lessen the need for thorough surgical treatment

A.T.S and A.G.G sera are given by intramuscular injection at the conclusion of the operation while the patient is still under the anaesthetic The recommended dosage is —

3 000 International units (I.U.) anti tetanic serum
9 000 International units (I.U.) *C. Welchii* anti toxin
4 500 International units (I.U.) *Cl. Septique* anti toxin
3 000 International units (I.U.) *Cl. Œdematiens* anti toxin

Now that supplies of penicillin are readily available this substance has replaced the sulphonamide group of drugs in the prophylactic treatment of compound fractures 20,000 units of sodium penicillin are administered intramuscularly every three or four hours for five days by either continuous or intermittent methods

The use of penicillin powder in the wound at the time of

should be drained by incision in their most dependent parts

The question as to whether or not to close the wound requires consideration. The exposed tissues should certainly be covered either by suture, by a skin graft, or by gauze if drainage is necessary. A great deal of judgment and experience is needed to decide which method to use and failure of any of the three is usually due to wrong application rather than any defect inherent in the method. It is quite certain that a wound should never be sutured if there is any tension on the skin, and for this reason few serious wounds can be closed. Also no surgeon of experience will suture a wound unless the patient is to remain under his personal care for the next ten to fourteen days. An immediate skin graft is an excellent dressing for shallow wounds in which there has been skin loss and is particularly applicable to compound fractures of the tibia when the wound is on the antero lateral or antero medial surface of the leg as it most often is

The policy of safety is neither to suture nor to graft but to cover the wound and at the same time drain it by means of lightly inserted dressing—an ordinary cotton bandage of two or four inches width is an excellent substance for this and is preferable to vaseline gauze as a first dressing

The surgical treatment or toilet as it is called of the wound is not quite the same if the patient cannot be dealt with until more than six hours after wounding. As before the wound is laid widely open by incision of skin and fascia and thorough cleansing of dirt and debris undertaken counter-drainage is instituted when necessary and hæmorrhage is controlled but wide excision of infected soft tissue is avoided and the wound is never sutured

**Support and Splinting** When the actual surgery has been completed the limb is enclosed in a well-fitting plaster cast. Bony prominences should always be padded but to produce the best effect in supporting and immobilising the tissues and preventing œdema the rest of the cast should be unpadded and well moulded to the limb. It is difficult to advocate the unpadded cast too strongly because the success of the method does depend so much on expert

top removed the limb is kept elevated and the patient is encouraged to move his toes

Swelling may be the earliest sign of *infection of the wound*, and will be accompanied by pain and a rise in the temperature If infection becomes established, the plaster must be removed the wound opened and all pockets of pus adequately incised and drained The wound is lightly dressed with gauze or cotton bandage impregnated with vaseline and a complete plaster cast reapplied The general alignment of the limb is maintained but any sort of manipulation to obtain accurate reduction of the fracture during an acute infection is out of the question The usual general measures to overcome infection are instituted including the administration of penicillin and sera

If the infection spreads to bone, as it does more often than not a chronic osteomyelitis will result The condition is much the same as that which follows an hæmatogenous acute osteomyelitis sequestra and sinuses form and removal of the sequestra by operation will eventually be required Union of the fracture will almost certainly be delayed until infection has cleared up and all sequestra have separated and have been removed

Tetanus and gas gangrene are possible complications of any compound fracture Prophylactic measures have already been described but for a description of these infections and their treatment the reader is referred to a text book of general surgery

**Amputation after Compound Fractures** Where the injury is confined to one limb the main indication for amputation is irreparable interference with the blood supply No matter how severe the destruction of the skin the comminution of bone or the contamination of tissues, if the main blood vessels are not destroyed the limb can usually be saved A surgeon who amputates because of the severity of the local injury assumes a grave responsibility—particularly in the case of the upper extremity—and a second opinion should always be sought before proceeding to this drastic step (Medical Research Council War Memorandum No 5 1941 )

operation has already been described The powder most frequently employed is a calcium penicillin and sulphonamide mixture containing 5,000 units of penicillin per gramme

**After-treatment of Compound Fractures** A patient with a compound fracture must be very carefully nursed and watched Provided no complications have arisen plaster and wound should remain undisturbed for fourteen days The state of affairs should then be reviewed If the fracture is in satisfactory position and there is no discomfort nor excessive discharge of pus from the wound, and the plaster remains effective nothing should be done till the end of a month If, however the fracture is not properly reduced and there is no infection of the wound or only infection of a granulating surface steps are then taken to get the fracture into good position Unless, however the wound is healed or the granulating surface small and clean, a pin must not be inserted afresh into the bone At the end of a month most compound fracture wounds unless healed by first intention will need dressing In addition the original or second plaster will by then have become loose The plaster is changed and the wound dressed, if necessary under general anæsthesia Often the discharge of pus from the depth of the wound or from superficial granulations will cause dermatitis which is both prevented and very well treated by the application to the whole limb of a 1 per cent aqueous solution of gentian violet

If there has been much loss of skin, a decision should be made on the fourteenth or twenty-eighth day on the advisability of skin grafting the granulating area Either pinch grafts or Thiersch grafts may be used depending on the local conditions

Once the wound has healed the treatment is that of a closed fracture of the same region

**Complications.** *Swelling* of the limb may occur after the limb has been enclosed in plaster The condition is no different from that which occurs in the treatment of closed fractures and it is better not to disturb the plaster However if swelling is causing embarrassment to the circulation in the foot and toes the cast is split along each side and the

calcium phosphate is deposited in the newly formed undifferentiated tissue

STAGE IV *Ossification* This newly formed callus is invaded by blood vessels growing out from the Haversian systems and marrow cavity of the bone ends The blood vessels carry with them into the callus cartilage cells osteoblasts and osteoclasts and bone is formed by a direct calcium-osteoblast reaction sometimes by ossification of preformed calcified cartilage Dead fragments of bone and unwanted new bone are removed by osteoclast action The substance consisting of connective tissue matrix calcium and islets and strands of bone is known as osteoid tissue

STAGE V *Bone Formation* The bone ends are now united by strands of bone crossing from under the periosteum, between cortex and cortex and joining the medullary cavities At first a good deal of connective tissue matrix remains but is gradually replaced by bone

STAGE VI *Trabeculation* The fracture has now united With time and the stimulus of active use trabeculæ reform and the medullary cavity may once again become continuous across the healed fracture

The timing of this fracture healing process is a matter of some difficulty and cannot be expressed accurately Of course the process is a continuous one and the different stages are not clear cut Stages I and II occur during the first twenty four to thirty-six hours after the injury callus formation has usually begun during the next seven to ten days and thereafter Stages III IV and V progress for a very variable time Clinical union of the fracture will have occurred during the replacement of osteoid tissue by bone but before the process is complete The final stages of trabeculation and reformation of the medullary cavity will not be completed until many months have elapsed

It should be realised that fracture healing is essentially a local process The fracture hæmatoma is a closed chemical factory almost uninfluenced by general blood calcium and

## Chapter V

# UNION SLOW UNION AND NON UNION

Before we consider delayed union and non union of fractures we should try to have a clear picture of how a fracture unites what is meant by union and how long the process will take The healing process for a fractured bone goes through successive stages which can be described briefly —

Stage I *Formation of the Fracture Hæmatoma* There has been injury to bone and periosteum a varying amount of damage to muscles bleeding and tissue death

Stage II *Hyperæmia and Decalcification* The local small blood vessels dilate and there is exudation of fluid the diluted hæmatoma becomes increasingly acid because of necrosis of the injured tissues with liberation of carbon dioxide lactic acid and conversion of blood sugar At the same time the hæmatoma and exudate begin to clot and a fibrin network is formed During this stage the bone ends become decalcified It seems probable that this decalcification is a vital process and due to cellular activity rather than a purely chemical reaction occurring in an acid medium

Stage III *Callus Formation* Primitive connective tissue cells from the marrow cavity the Haversian canals the periosteum and endosteum, and from the sheath of the torn muscle bundles begin to grow into the fibrin network As a result of decalcification of the bone ends there is an accumulation of organically bound phosphoric acid and calcium salts The products of local tissue death are gradually absorbed and as they disappear the pH of the medium rises until it becomes alkaline this allows the enzyme phosphatase to become active and

will vary with the different bones and with the site and position of the fracture For instance it is obvious that more consolidation will be required in a bone which has to bear weight than in one which does not that the strains on a uniting fracture will be greater in the middle of the shaft of a long bone than at its ends and that a fracture in which there is very little end to-end apposition will require a solid bar of bone to unite the ends securely

There are certain clinical signs which indicate that a fracture is not united and that it would be unsafe to discard the protection of a splint Movement between the bone ends when the fracture is tested is, of course an obvious sign, if there is no apparent movement but the patient complains of pain at the site of the fracture on testing for movement or if there is no movement and no pain on testing but the fracture is still tender on palpation then it is not united After the splint has been discarded there may be some swelling particularly in fractures of the lower limb but if on removing the splint local œdema is present at the level of the fracture, this strongly suggests that union is still incomplete. We may say then that a fracture is probably united if there is

No movement of the bone ends on testing the fracture,
No local œdema
No local tenderness
No local pain on attempting to force movement

In some bones such as the clavicle the metacarpals and metatarsals and in most Colles' fractures clinical signs are enough, but in other bones particularly the femur and tibia which bear the weight of the body, X ray confirmation of union is necessary, and in these fractures until an X ray shows a certain degree of consolidation protection must be continued.

In deciding whether union has occurred we must never let ourselves be influenced by the time during which a fracture has been splinted but only by actual clinical evidence of union usually confirmed by an X ray This end point at which the protection of a splint can be discarded and the fracture is said to be united is reached

blood phosphatase levels or the secretion of endocrines However the process is not entirely a chemical one and it may be that the formation of the connective tissue matrix is influenced by vitamin C deficiency in the same way that lack of this vitamin will influence the healing of wounds in other tissues

The altering X ray appearance of a fracture which is uniting normally can also be differentiated into stages At first the edges of the bones are clear cut In a week or two they become less definite presenting an eroded moth-eaten appearance this erosion is the evidence of decalcification and as a result of this process the fracture line may seem to increase in width. When callus forms it appears round the shafts of the bone as a shadow extending proximally and distally in an irregularly fusiform manner—and has been likened to a plumber s wiped joint Later on the callus becomes ossified the shadow becomes smaller but denser and at the same time the fracture line and the medullary cavity above and below it become filled with new bone The shadows of callus and new bone differ to the experienced eye so that it is possible to judge the extent to which real bony union has occurred from the X ray As the process of healing continues excess callus and new bone are absorbed, the cortex is restored to its normal shape and density and bony trabeculæ reappear much later the medullary cavity may be seen to have reformed but this does not always occur These progressive X ray appearances can be summarised as absorption callus formation ossification consolidation and finally trabeculation

A fracture is regarded as being united when repair is sufficiently advanced, for the protection of a splint to be discarded Callus alone is not strong enough to resist the strains to which a limb is subjected by ordinary use on the other hand the final stage of trabeculation will not have been reached until many months after the fracture has become joined solidly by bone It is during the stages of ossification and consolidation that union occurs and the degree to which consolidation of the newly forming bone must have pro gressed before the protection of a splint becomes unnecessary

will vary with the different bones and with the site and position of the fracture For instance it is obvious that more consolidation will be required in a bone which has to bear weight than in one which does not, that the strains on a uniting fracture will be greater in the middle of the shaft of a long bone than at its ends and that a fracture in which there is very little end to-end apposition will require a solid bar of bone to unite the ends securely

There are certain clinical signs which indicate that a fracture is not united and that it would be unsafe to discard the protection of a splint Movement between the bone ends when the fracture is tested is of course an obvious sign if there is no apparent movement but the patient complains of pain at the site of the fracture on testing for movement or if there is no movement and no pain on testing but the fracture is still tender on palpation then it is not united After the splint has been discarded there may be some swelling particularly in fractures of the lower limb but if on removing the splint local œdema is present at the level of the fracture, this strongly suggests that union is still incomplete. We may say then that a fracture is probably united if there is

No movement of the bone ends on testing the fracture
No local œdema
No local tenderness
No local pain on attempting to force movement

In some bones such as the clavicle the metacarpals and metatarsals and in most Colles' fractures clinical signs are enough, but in other bones particularly the femur and tibia which bear the weight of the body, X ray confirmation of union is necessary, and in these fractures until an X ray shows a certain degree of consolidation protection must be continued.

In deciding whether union has occurred we must never let ourselves be influenced by the time during which a fracture has been splinted but only by actual clinical evidence of union usually confirmed by an X ray This end point at which the protection of a splint can be discarded and the fracture is said to be united is reached

blood phosphatase levels or the secretion of endocrines However the process is not entirely a chemical one and it may be that the formation of the connective tissue matrix is influenced by vitamin C deficiency in the same way that lack of this vitamin will influence the healing of wounds in other tissues

The altering X ray appearance of a fracture which is uniting normally can also be differentiated into stages At first the edges of the bones are clear cut In a week or two they become less definite presenting an eroded moth-eaten appearance this erosion is the evidence of decalcification and as a result of this process the fracture line may seem to increase in width When callus forms it appears round the shafts of the bone as a shadow extending proximally and distally in an irregularly fusiform manner—and has been likened to a plumber s wiped joint Later on the callus becomes ossified the shadow becomes smaller but denser and at the same time the fracture line and the medullary cavity above and below it become filled with new bone The shadows of callus and new bone differ to the experienced eye so that it is possible to judge the extent to which real bony union has occurred from the X ray As the process of healing continues excess callus and new bone are absorbed the cortex is restored to its normal shape and density and bony trabeculæ reappear much later the medullary cavity may be seen to have reformed but this does not always occur These progressive X ray appearances can be summarised as absorption callus formation ossification consolidation and finally trabeculation

A fracture is regarded as being united when repair is sufficiently advanced for the protection of a splint to be discarded Callus alone is not strong enough to resist the strains to which a limb is subjected by ordinary use on the other hand the final stage of trabeculation will not have been reached until many months after the fracture has become joined solidly by bone It is during the stages of ossification and consolidation that union occurs and the degree to which consolidation of the newly forming bone must have pro gressed before the protection of a splint becomes unnecessary

movement, and often palpable movement of the bone ends on each other when the fracture is tested. The X ray appearances of non union are characteristic There is no evidence that bone is forming across the gap between the fragments and a line of increased density can be seen crossing the end of the medullary cavity and the cortex transversely in one or both fragments This shadow indicates that a band of sclerotic bone is blocking both cortex and medulla and is evidence that the process of healing by bone has been interrupted and will not be resumed It is thus sclerosis of the bone ends which differentiates non union from slowly progressing union and indicates the need for special treatment

Non union can be divided into three types —

(1) Union by fibrous tissue ,

(2) Absolute non union, when the ends of the bone are quite free from each other and may be separated

(3) Pseudo arthrosis or formation of a false joint

Of the three fibrous union is by far the commonest Sometimes the bone is united so firmly by fibrous tissue that it hardly seems strictly correct to call the condition non union When the strength of a bone lies in its ability to withstand a longitudinal pull as in the case of the patella or olecranon strong fibrous union may cause no disability provided the fragments are in close apposition and the patient may be quite unaware that bony union has not occurred But when lateral stability is required as in the shaft of a long bone fibrous union allows bending at the site of fracture and weight bearing is painful

(2) Absolute non union is most commonly found when part of the bone has been lost, either by destruction at the time of a compound fracture or as a sequestrum after infection Sometimes however the fragments have been separated by distraction or sometimes union has been prevented by the interposition of a mass of fascia or muscle

(3) Pseudo-arthrosis is nowadays an uncommon variety of non union It occurs when movement or weight bearing has been allowed before the fracture has united. This improper use of the limb with the fracture ununited must

after very different periods of time in fractures of the various bones Ordinary experience shows that the time for union —to take a few examples—is something like three weeks for the clavicle, six weeks for a Colles fracture fourteen weeks for the femur, sixteen to twenty weeks for the tibia and sometimes very much longer for the carpal scaphoid Furthermore it is a common observation that compound fractures as a rule unite more slowly than closed fractures especially if the wound has become infected If a fracture has been difficult to reduce or has had to be manipulated and remanipulated to restore the original position then it will take longer to unite than the fracture which is successfully reduced at once and in which the position remains unaltered. Such fractures as those at the junction of the mid and lower third of the tibia the middle of the shaft of the humerus the lower third of the ulna transverse fractures of the femur and tibia when end to end apposition of the ends of the bone is poor and comminuted fractures of long bones in which there is a large butterfly-shaped fragment—all these take longer to unite than others The time which fractures take to unite is subjected to very considerable variation and it does no harm to repeat that we must not allow ourselves to be influenced by any definite time in weeks but must wait patiently for clinical and X ray evidence that union has occurred

**Delayed Union** Without adopting some arbitrary period it is difficult to say that union is in any way delayed and the use of the term delayed union suggests that there is some malign influence at work whereas all that is usually meant is that union is proceeding more slowly than expected. Slow union is a more accurate description

**Non union** If the process of healing by bone has ceased before the fracture is united then non union is present. Non union is a pathological entity with clinical signs distinctive X ray appearances and a definite morbid anatomy

The clinical signs are not specific and are those which suggest that the fracture has not joined—local œdema of the limb local tenderness pain on attempting to force local

(3) Interposition of soft parts between the bone ends,
(6) Loss of blood supply to one or both fragments,
(8) Too much movement at the site of fracture

INFECTION Infection does not necessarily result in non union but union is inevitably slow because every stage of repair is delayed Owing to bone loss or sequestration a gap may have to be bridged by bone—moreover, the presence of an inflammatory reaction necrotic tissue and pus prevent the deposition of calcium Throughout this stage granulation tissue between the bone ends is susceptible to shearing and rotation strains

LOCAL BONE DISEASE Fractures through bone cysts or even giant cell tumours and some cancerous deposits often heal rapidly and completely Fractures of bones affected by osteitis fibrosa cystica are slow in uniting because the bones are poor in mineral content and in Paget s disease may heal slowly owing to the lack of mesoblastic tissue Fractures through the osteolytic types of sarcoma and secondary carcinoma are unlikely to heal at all

DISTRACTION When a bone is overlengthened so that there is a gap between the bone ends this is known as distraction The most usual cause is excessive traction when weight extension is being used, but distraction does not necessarily involve suspension of a weight from the limb Methods of skeletal transfixion with incorporation of pins in mechanical devices or in a plaster cast are no less potentially harmful Over pull during the first few hours before the fracture hæmatoma is replaced by granulation tissue appears to be unimportant but distraction at any later stage inhibits bone formation, promotes fibrous tissue growth and causes inactivity of the fractured surfaces. The radiographs show a characteristic appearance of indolence which is in striking contrast to the heaped up callus formation around the sides of a fracture subjected to excessive movement

INTERVENING SOFT PARTS The interposition of muscle or fascia is probably an unusual cause of non union. Less common nowadays than in the past because the interfering tissue prevents accurate reduction of the fracture The persistent mal position is diagnosed early by X ray and

continue for some considerable time before a characteristic false joint is formed When the condition has become established the end of one fragment is eburnated smooth and convex, the end of the other concave and distorted by bony outgrowth from the periphery of the fragment The fibrous tissue surrounding the ends of the bone forms a pseudo capsule."

The causes of slow union and non union may be divided into general conditions of the patient and local conditions at the site of fracture

With regard to the general causes a vast literature has accumulated on the subject of constitutional and dietetic errors in relation to the union of fractures Consideration has been given to calcium and phosphorus metabolism, diet and general metabolic deficiencies parathyroid and ovarian secretions local and plasma phosphatase and vitamin deficiencies Eliason whose view certainly seems correct may be quoted when he says Most text books mention constitutional diseases such as the neuropathies tabes syringomyelia scurvy exhausting diseases resulting in nutritional or metabolic disturbances osteomalacia fragilitas ossium, hypopituitarism and possibly senility the latter only so far as it interferes with the general health. Recently certain writers as Cotton Speed Roberts Kelly *et al* have shown by statistics that although these conditions contribute to pathological fracture only a few such as scurvy tabes and wasting conditions really interfere with union.

Our knowledge of the healing of fractures suggests as has already been described that the process is essentially a local one involving the formation of a closed chemical factory in the hæmatoma and the development of a specialised connective tissue matrix between the bone ends

Chief amongst the local conditions which will interfere with union are —

(1) Infection
(2) Local bone disease
(3) Distraction or separation of the bone ends by excessive traction,

fracture and it seems by no means unlikely that if this delaying influence is continued for long enough the process of ossification across the gap will cease altogether and non union will become established These strains at the site of fracture are permitted or caused in several ways First by unsuitable or ineffective splinting Failure to splint the fracture at all although it often leads to non union may not be such an evil influence as the splint or plaster which although firmly fixed or moulded to the distal part of the limb fails altogether to fit the proximal part so that by its weight alone it increases the strain on the fracture site Potent amongst the causes of non union is the badly applied walking plaster or weight bearing plaster which again does not secure the proximal fragment so that every step which the patient takes produces a considerable strain at the fracture many walking or weight bearing plasters indeed any type of plaster cast may be satisfactorily applied in the first instance but gradually becomes ineffective and finally harmful if not examined by a properly trained eye and hand at frequent intervals

Then again it is not always recognised that careless handling of the limb at a time when it is being replastered may cause strain which amounts to refracture In slowly uniting fractures and infected fractures where there is often a gap between the fragments this is particularly important Union may never take place if the bone is refractured at regular intervals every time the plaster is changed

Strains are a likely cause of non union in fractures at certain special sites where immobilisation of proximal or distal fragments is particularly difficult Such sites are the neck of the femur and the waist of the carpal navicular

Finally if the protection of a splint is discarded before the fracture is sufficiently firm the uniting tissue will be subjected too early to stress and non union will result An obvious type of strain which may cause damage in these cases is too early weight bearing after a fracture of the tibia or the femur A less obvious example is the repeated strain on a fracture of the shaft of the femur which results from active and particularly passive attempts to regain

the intervening soft parts are removed from between the fragments by an operation before the process of union has been delayed and stopped as in transverse fractures of the medial malleolus of the tibia in which a fragment of periosteum very frequently becomes interposed between the bone ends and must be removed at operation otherwise non union always occurs

LOSS OF BLOOD SUPPLY The blood supply to a bone is through the nutrient artery the periosteal arteries and the metaphyseal arteries If one of these sources of blood is cut off collateral circulations are established from the others but the time taken to establish these collateral circulations varies considerably Loss of the nutrient artery cannot be compensated for before a fortnight or three weeks During that period no embryonic mesoblastic tissue will be formed from the marrow cavity the endosteum or the vast majority of the Haversian canals Therefore if a fracture occurs in the area of a nutrient artery and involves it a long period of immobilisation is necessary before the reparative process can begin Union will anyhow be slow and if this period of delayed growth is not anticipated and allowed for non union is apt to occur The best examples of this process are seen in fractures of the middle of the shaft of the humerus and of the tibia Other examples are fractures of the neck of the femur and some fractures through the waist of the carpal navicular but here the situation is severely complicated by another factor each of these fractures is extremely difficult to immobilise and protect from shearing and rotatory strains so that non union is far more likely to occur and in the case of the femoral neck was almost *inevitable before the conception of the Whitman plaster and* the Smith Petersen nail

EXCESSIVE MOVEMENT AT THE SITE OF FRACTURE. It has already been pointed out that although rigid immobilisation is unnecessary intermittent strains of a shearing bending and rotational nature must tend to break up the delicate network of healing tissue between the bone ends Every tissue rupture must lead to delay whilst fresh tissue is growing and to a slow-down in the rate of ossification of the

theoretical grounds by giving calcium as is found by practical experience.

**Treatment for Non-union** is not always necessary when there are no symptoms. Some fractures of the medial malleolus of the tibia, the patella, the olecranon and the transverse processes of the lumbar vertebræ may unite so strongly by fibrous tissue that although the X-ray indicates that there is non-union, function remains unimpaired. Usually, however, symptoms of pain or instability, or both, accompany non-union, particularly in the bones of the lower limbs which have to bear the weight of the body. There is only one effective method of treating non-union and that is by a bone-graft. No matter which of the three types of non-union is present, the treatment is the same.

It is not proposed to go into the technical details of operation for bone grafting, but a few general points need emphasis. The operation is one which calls for the very best surgical skill and facilities and for experience in bone surgery. As a first step in the actual operation the ununited fracture must be reduced as accurately as possible. It is probably best to remove all sclerotic bone and fibrous tissue from between the bone ends, although Elmslie has shown that if an autogenous bone graft is used this step may not be absolutely necessary. The graft should be of living autogenous bone, either of cortical bone from the uninjured part of the same bone or from another bone, usually the tibia, or else chips taken from the cancellous bone of the ilium. Cancellous bone is better used when there is a gap between the fragments which has to be filled; quite often cortical bone and cancellous chips are used in combination. If a cortical graft is used it must be fixed securely in position either by slotting it into the bone or by the use of metal screws. It does not seem to make any difference whether the periosteal covering of the graft is preserved or not. After a bone graft the protection of a well-fitting plaster cast is as necessary as in the treatment of a fresh fracture.

The use of beef bone pegs, intra-medullary grafts or metal plates and wires in the treatment of non-union is mentioned only to be condemned.

movement in the stiffened knee joint or again the rotatory strains exerted on a fracture of the shaft of the ulna in its lower third when the inferior radio-ulnar joint is being mobilised In both these examples the dense fibrous adhesions in knee joint or radio ulnar joint may be stronger than the ossifying callus at the fracture

The general and local conditions which have been discussed in the preceding paragraph are those which will cause union to be slow The reasons why these should cause delay in union are fairly easy to understand although very often more than one delaying factor may be at work However it is not at all clear why the process of union sometimes stops altogether although the result of cessation of healing is seen in the blocking of each fragment by sclerotic bone It seems likely that it is the continuous or repeated effect of an uncorrected delaying factor which will eventually stop the normal healing process and establish the condition as non union Amongst local causes the only ones which are certain to produce non union are the interposition of soft tissue and such wide separation of the fragments either by displacement or by bone loss that union cannot occur

Slow union does not inevitably lead to non union The two conditions are differentiated by the appearance in an X ray of a line of sclerosis at one or both bone ends which is the sign that non union is established. This distinction is of great importance because the treatment of slow or delayed union and that of non union is entirely different.

**The treatment of slow union** can be epitomised as prolonged splinting and patience In addition it is important to preserve the local circulation and tissue exchanges as far as possible by active exercises and functional use of the limb Although the patient s general condition should be maintained at the highest level little advantage seems to be gained from any special diet or drugs The majority of patients with ununited fractures show no abnormality in the calcium content of the blood nor any departure from the normal blood chemistry Furthermore the average person takes daily more calcium than he can absorb It would seem therefore that as little can be hoped for on

## Chapter VI

# SOME COMPLICATIONS OF FRACTURES

*Shock haemorrhage gas gangrene tetanus septicaemia* and *local infection* of wounds may all complicate the treatment of a fracture Accompanying fractures which are the result of severe accidents there may be *injuries to the skull and brain to the lungs* or to *the abdominal viscera* The treatment of these conditions is in no way altered by the presence of a fracture and any description is unnecessary here but effective early treatment of the fracture may often assist recovery from a more serious injury Obviously the restless ness of a patient with cerebral injuries may be increased by painful stimuli from an unreduced and unsplinted fracture and a comfortable rather than an uncomfortable limb will assist the patient s resistance to an infected hæmothorax pneumonia or acute peritonitis

On the other hand associated injuries may have consider able influence on the local treatment of fractures In many cases another injury or injuries must have priority of treat ment over the fracture but the temptation to postpone any consideration of a fracture until the patient has recovered or almost recovered from his more serious injuries must be resisted Two inches of shortening in the leg lessens the gratitude of a patient whose life has been saved by a brilliant cranial decompression ! The treatment of shock can be so effective that more often than not it is the best policy to deal with all the injuries at the same session

*Burns* and a fracture of the same limb can present a very difficult problem The swelling of the limb which accom panies a fracture tends to retrogress as soon as the fracture is properly reduced and splinted Not so the œdema which follows severe burns Swelling from this cause seems to increase for a few days in spite of proper treatment and rest so that the use of an unpadded plaster over a burnt limb is

Although the treatment of slow union and non union has been described first prevention is of primary importance The main points for careful attention are these —

(1) Avoid infection of compound fractures by efficient treatment in the earliest stage

(2) Be on the look-out for distraction when traction methods or pin fixation are in use

(3) Recognise those cases in which intervening soft tissue is the cause of failure to reduce the fracture accurately

(4) Excessive movement at the site of a uniting fracture is produced by frequent remanipulation and is avoided by gentle handling of the limb during *application and particularly removal of the cast* by the application of a plaster which is effective in controlling both fragments and thus preventing harmful movement between them and by proper inspection of the plaster at frequent intervals during treatment to see if it remains effective Careful supervision is particularly required for weight bearing plasters

(5) Take great care in estimating when union has occurred It is far better to keep the fracture splinted for a little too long than to discard protection before the fracture has united

been reduced and a splint applied it is seldom feasible to get at enough of the limb for complete examination However there are a few simple muscle tests which can and should be applied which in most cases will tell whether or not a nerve has been injured In testing for voluntary motor power it is contraction of the individual muscle which is to be observed not movement of a joint, so-called trick movements are common, and it is only necessary to see one patient with a full range of active movement at the shoulder in spite of complete paralysis of the deltoid muscle to realise the importance of this observation

The peripheral nerve lesions for consideration here are —

*The Brachial Plexus* Injury to the whole or part of the plexus happens as a result of wrenching when the injury occurs It may complicate any fracture of the upper limb and is not confined to injuries of the shoulder joint and clavicle Motor and sensory disturbance are more wide spread than can be accounted for by an isolated nerve injury and in addition palpation in the supra-clavicular fossa often reveals a swollen and tender plexus

*The Circumflex or Axillary Nerve* Injury to this nerve with paralysis of the deltoid and sensory loss over a small area on the outer side of the upper arm frequently occurs as a complication in dislocations of the shoulder or fractures of the upper end of the humerus

*The radial nerve* is particularly liable to injury in fractures of the middle third of the shaft of the humerus and its posterior interosseous division when the neck of the radius is fractured.

*The ulnar nerve* is most commonly involved in injuries to the elbow especially fracture of the medial epicondyle of the humerus Ulnar neuritis may develop as a late complication sometimes years after a *supracondylar fracture* or other injury to the lower end of the humerus which has resulted in a valgus deformity of the elbow

*The median nerve* is often damaged at the wrist joint by a dislocation of the lunate but apart from this common lesion the median nerve is rarely injured as a result of fracture

always fraught with considerable risk of obstruction to the local circulation

*Multiple fractures* call for systematic thinking and for a good memory Such injuries as a mallet finger fracture of a metacarpal or metatarsal or fracture of the carpal scaphoid are very easily missed or forgotten in the excitement of the more intriguing injuries to the larger bones but nevertheless reap their full harvest of disablement at the end of treatment

**Nerve Injuries** Injury to a peripheral nerve may accompany a fracture and although it is not a common occurrence it is wise to exclude this complication at the initial examination of any fracture The nerve may be *injured (1) by direct violence of the injury which produces* the fracture (2) by impact on the nerve of the fractured bone as it becomes displaced (3) by overstretching during the wrenching of the limb which produces a dislocation or fracture (4) by the pressure of a splint It is possible that a nerve may on occasions be compressed by callus but this appears to be a very rare cause of injury and the fact that a nerve lesion becomes apparent late in the history of a fracture is more often because the diagnosis has been missed at the initial examination of the limb

The clinical signs of a peripheral nerve injury are —

(1) Loss of motor power and subsequently wasting of those muscles normally activated by the nerve
(2) Sensory disturbance in the area of the limb supplied by the nerve
(3) Absence of sweating over the same sensory area

The nerve may not be completely divided so that wasting and paralysis sensory loss and absence of sweating will not be always total Furthermore a nerve may be injured or divided below the level at which some of its main branches have been given off so that the more proximal muscles and parts of the skin supplied by that nerve remain unaffected

Detailed investigation of nerve function is quite impossible during the examination of a case of fracture because before the limb has been splinted, muscle spasm and diffuse pain in the limb obviate proper testing After the fracture has

occurs as a result of complete inward dislocation of the knee Lesion of the posterior tibial nerve is rare as a complication of fractures The action of the muscles supplied by the sciatic nerve and its branches can be tested without much difficulty The area of sensory loss even in a complete sciatic nerve lesion is very limited because the long saphenous nerve the lateral cutaneous nerve and the small sciatic nerve supply the greater part of the skin of the leg and inner border of the foot In addition the lesion is often below the branches which form the sural nerve and supply part of the outer side of the ankle and heel

**Principles of Treatment** (1) Stiffness and contracture of joints should be prevented by active and passive movements

(2) The volume of muscles should be preserved by daily galvanic stimulation and recovery should be assisted by re-educational exercises

(3) Paralysed and recovering muscles should be protected from overstretching but mobility of joints must not be interfered with by splinting

In this connection it should be noted that rigid splinting is far more deleterious to recovery of function than is an unsupported muscle

When a fracture has to be treated in plaster at the same time it is often difficult and may be impossible to carry out all these principles in treating a nerve lesion However when there is an associated radial nerve or ulnar nerve lesion it is very important to prevent contracture and stiffness of the metacarpo phalangeal and interphalangeal joints It is also important in these conditions to allow for galvanism to the extensor muscles of the wrist and fingers or to the intrinsic muscles of the hand through windows cut in the plaster cast Injuries of the shoulder and some fractures of the humerus should usually be treated on an abduction splint if there is a lesion of the axillary nerve or of the brachial plexus

**Exploration and Suture of Divided Nerves** When a nerve is found to be divided in a case of compound fracture it should not be sutured but the proximal and distal stump

*The action of these nerves* can be tested quite easily and in a simple manner without undue disturbance

*For the radial nerve* make the patient extend his wrist watching and feeling the extensor carpi radialis longior and brevis contract

*For the posterior interosseous nerve* make him extend his fingers at the metacarpo phalangeal joints and the thumb at the interphalangeal joint also Feel the muscle bellies contract and watch the long extensor tendon of the thumb stand out

*For the ulnar nerve* note that the long extensor will also abduct the fingers therefore test the action of the inter osseous muscle by making the patient abduct and adduct the fingers individually and with the hand flat if possible on a smooth surface The first dorsal interosseous muscle and the hypothenar muscles can be felt to contract It may be fairly easy to test for sensory loss on the ulnar side of the palm and on the palmar surface of the fifth digit

*For the median nerve* remember that the lesion is very often distal to the branches of supply to the muscles which flex the interphalangeal joints of thumb and index finger and that all the intrinsic muscles of the hand except the abductor brevis pollicis may be supplied by the ulnar nerve To test the abductor brevis pollicis the thumb must be lifted away from the palm in a plane at right angles to the palm and the patient told to keep the thumb in that position against resistance If the muscle is acting it can be felt and often seen lying along the shaft of the first metacarpal Confirmation of a median nerve lesion can be made by finding sensory loss on the radial side of the palm and on the palmar surface of the index finger

*The Sciatic Nerve* This nerve is sometimes injured by a posterior dislocation of the hip or fracture of the shaft of the femur Its lateral popliteal division provides the commonest examples of nerve damage from pressure splints The nerve may be compressed by the side bar of a Thomas s splint or the upper end of a walking plaster The lateral popliteal nerve may be injured in a fracture of the neck of the fibula and a particularly severe traction lesion of the nerve

occurs as a result of complete inward dislocation of the knee Lesion of the posterior tibial nerve is rare as a complication of fractures The action of the muscles supplied by the sciatic nerve and its branches can be tested without much difficulty The area of sensory loss even in a complete sciatic nerve lesion is very limited because the long saphenous nerve the lateral cutaneous nerve and the small sciatic nerve supply the greater part of the skin of the leg and inner border of the foot In addition the lesion is often below the branches which form the sural nerve and supply part of the outer side of the ankle and heel

**Principles of Treatment** (1) Stiffness and contracture of joints should be prevented by active and passive movements

(2) The volume of muscles should be preserved by daily galvanic stimulation and recovery should be assisted by re-educational exercises

(3) Paralysed and recovering muscles should be protected from overstretching but mobility of joints must not be interfered with by splinting

In this connection it should be noted that rigid splinting is far more deleterious to recovery of function than is an unsupported muscle

When a fracture has to be treated in plaster at the same time it is often difficult and may be impossible to carry out all these principles in treating a nerve lesion However when there is an associated radial nerve or ulnar nerve lesion it is very important to prevent contracture and stiffness of the metacarpo phalangeal and interphalangeal joints It is also important in these conditions to allow for galvanism to the extensor muscles of the wrist and fingers or to the intrinsic muscles of the hand through windows cut in the plaster cast Injuries of the shoulder and some fractures of the humerus should usually be treated on an abduction splint if there is a lesion of the axillary nerve or of the brachial plexus

**Exploration and Suture of Divided Nerves** When a nerve is found to be divided in a case of compound fracture it should not be sutured but the proximal and distal stump

should be anchored in position by one or two catgut stitches Repair of a nerve known to be divided or exploration of a nerve lesion in a closed fracture is not undertaken until the wound has healed and the fracture united

It appears that although there is nothing to be gained by primary suture delay of more than two or three months is to be avoided if possible because of the excessive formation of scar tissue loss of mobility in joints and atrophy of muscles which occur For this reason it is more than ever important that the fracture should be treated with the utmost expert care so that healing and union may take place without loss of time

**Vascular Injuries** Bruising and swelling from injury *to blood vessels are the natural accompaniment of most* fractures It is only when a main vessel is torn that hæmorrhage is really serious although with an open fracture there may be a considerable loss from medium-sized vessels

The main vessels such as the axillary or femoral may be torn or may be so compressed as completely to interrupt the circulation Pressure may arise from a projecting fragment of bone from splints or from increased tension in the tissues due to hæmorrhage Pressure on vessels is liable to be a more serious complication than hæmorrhage because it is more likely to be overlooked and the continued pressure on the vessels may cause gangrene of the distal part of the limb

The blood vessels at the elbow may be compressed as the result of tight splinting and bandaging of the limb If a normal elbow is fully flexed the radial pulse is obliterated If this is realised, it is easily understood how readily the veins may be compressed when the elbow is flexed in the presence of great swelling It is unwise and unsafe to flex the elbow fully following a fracture in that region and in many cases it is unsafe to flex the elbow to less than a right angle The presence of swelling is no excuse for delaying reduction on the contrary it is the very reason for reducing the fracture as soon as possible When there is much swelling around *the elbow joint so that it is likely to interfere* with the circulation, the latter will be helped by elevating the limb until the elbow is above the level of the shoulder

After reduction of a fracture in the region of the elbow it is not sufficient to feel the radial pulse but the colour of the hand and the condition of the superficial veins must also be noted Blueness of the hand and venous congestion are danger signs, if these are present and the fracture has been properly reduced so that there is no possibility of a fragment of the humerus pressing on the vessels the elbow should be extended a little more and the whole arm elevated It is only when this has been done and venous congestion persists that one is ever justified in incising the skin and deep fascia of the forearm to relieve tension in the underlying tissues This procedure is rarely called for, but it is occasionally indicated and has been known to be of great value

In the veins thrombosis may occur and cause troublesome and persistent swelling of the limb Pulmonary embolism sometimes follows a fracture in the lower extremity particularly of the neck of the femur In one case a large and immediately fatal embolism occurred while manipulating a fracture of the neck of the femur on the fourth day after the accident

Following any fracture there is likely to be swelling in the distal part of the limb but this is seen particularly in the lower extremity in middle-aged and elderly subjects Whether this is due to a lesion of the lymphatics capillaries or veins will not be discussed here but œdema is so constant a sequel of a fracture in the lower limb that its treatment should be entirely preventive While the foot and ankle are in a close fitting plaster cast œdema cannot occur and if when the plaster is removed an Elastoplast bandage is put on from the toes to the tuberosity of the tibia œdema will be prevented As ordinary movements of the ankle are carried out and the circulation gradually returns to normal the Elastoplast bandage can be left off without swelling occurring

**Volkmann s Ischæmic Paralysis** This condition is well known but rarely seen it most usually affects the long flexor muscles of the wrist and fingers but a similar condition can occur in the muscles of the leg and toes The syndrome consists in obstruction to the blood supply of a muscle or

group of muscles which causes immediate paralysis and is followed very rapidly by contracture of the muscle and deformity The pathology of the condition is now well recognised as a massive necrosis of the muscle concerned Both macroscopic and microscopic appearances resemble infarction and are quite different from those changes which occur either as the result of direct injury venous obstruction or of paralysis from interference with the nerve supply to the muscle Onset is usually within a few hours of injury but may sometimes be after an interval of days The earliest signs are those of obstruction to the arterial circulation with pallor or cyanosis of the limb absence of the distal pulse and lowered skin temperature it is well to remember that ischæmia may occur entirely without pain Once flexion of the fingers and pain on forcing extension is present it indicates that irreversible muscle changes have occurred and treatment to relieve ischæmia then will be too late and quite ineffective

When the condition of Volkmann s ischæmic paralysis with contracture has fully developed the hand is so useless and so little can be done for it that the importance of carefully observing the condition of the circulation in the hand and arm cannot be too strongly emphasised. The appearance of a fully developed ischæmic paralysis is characteristic the wrist and fingers are in a position of flexion and cannot be extended when an attempt to extend the fingers is made it is only successful if the wrist is flexed still more and in doubtful cases this test will serve to differentiate the condition from Dupuytren s contracture of the palmar fascia in which the position of the wrist has no influence on movements of the fingers

In the severest type of ischæmic paralysis the patient has no power of voluntary flexion of the fingers but in a number of cases the muscle fibres have not all been destroyed and a little active flexion may be preserved

If during the treatment of a fracture in the region of the elbow it is realised that Volkmann s paralysis has occurred the fingers and wrist should be splinted in a hyperextended position to prevent contracture of the flexor muscles

Movements should be carried out once a day *to prevent* stiffness but during the rest of the time the hyperextended position must be maintained as contraction may develop very rapidly

When the deformity has fully developed the outlook for a useful functioning hand is extremely poor Fingers and wrist may be gradually but forcibly extended or as suggested by Max Page the flexor tendons may *be detached at their* origin from the internal epicondyle of the humerus and slid down the forearm for some distance

To stretch the flexor muscles the wrist should be flexed so that the fingers may be fully extended at the inter phalangeal joints A straight metal splint is then fixed on the palmar surface of each finger and a straight splint bandaged securely on to *the hand to extend the metacarpo* phalangeal joints Only after the course of some days when these joints have gradually been fully extended should any attempt be made to extend the wrist With the finger joints straight and kept so by splints a good pull may be obtained on the flexors of the fingers as the wrist is gradually straightened.

*Lengthening of the tendons* by *open operation* and shortening of the radius and ulna have also been recom mended but whatever the treatment instituted for a fully developed Volkmann s ischæmic paralysis the functional result is poor

From the foregoing paragraph it is clear that treatment to relieve arterial obstruction and ischæmia of the muscles *must be instituted before contracture begins* The condition of Volkmann s ischæmia is now recognised as caused by spasm of the brachial artery following an injury to the wall of the vessel The lesion is usually a contusion or there may be a small hæmatoma but laceration or actual rupture of the artery are uncommon in this connection The damage may occur at the time of fracture or during a manipulative reduction and it appears that spasm may be kept up if the artery is caught against the projecting lower edge of the upper fragment in an unreduced supracondylar fracture of the humerus

Prophylaxis therefore includes early reduction of fractures of the lower end of the humerus with great care and gentleness in manipulation of the fragments Once spasm has occurred as evidenced by the signs of arterial obstruction need for treatment is urgent If so far untreated the fracture must be reduced at once and the elbow immobilised without pressure on or constriction of the tissues in front of the elbow If in spite of this arterial circulation is not restored the brachial artery must be exposed by operation in the ante-cubital fossa The damaged area is identified, and if injection of Papaverine does not relieve spasm, the injured segment is excised between ligatures The effect of this is to relieve reflex spasm of the artery and its branches and allow the rapid development of a collateral circulation

**Traumatic Myositis Ossificans** In this condition there is formation of bone in the muscles It is met with most commonly in the ante-cubital fossa and in the muscles on the anterior aspect of the thigh The ossification which occurs in the adductor longus muscle (Rider s bone) is another instance of this condition and has possibly the same pathology Traumatic myositis ossificans in the *region of the elbow more commonly follows a fracture-*dislocation than a fracture alone The typical clinical picture is that of an elbow joint which, following a severe injury remains stiff and does not make the progress towards recovery of movements that might be expected after five or six weeks an X ray examination will show a shadow at first fluffy and ill-defined but later becoming more dense anterior to the joint and usually in the position of the brachialis anticus and definitely separated from the bone The last fact suggests that this condition is something other than excessive callus formation from the fracture It has been suggested that by the violence of the injury osteogenic cells become displaced from the periosteum into the muscle As soon as this ectopic bone formation has been recognised the elbow should be put at complete rest preferably in a plaster cast as movements aggravate the condition and increase the amount of bone formation The elbow should be X rayed *when the plaster is changed about every two*

months, and after some months the shadow in the brachialis anticus will be seen to be getting smaller, when it has *disappeared (which is rare), or* reached a stationary size and has a well-defined outline movements of the elbow may be begun. If a large mass of bone remains in front of the elbow joint and blocks movement it should be removed but a small fragment may be left

Some authorities have advised that as soon as the condition of a traumatic myositis ossificans is diagnosed the portion of affected muscle should be excised and the area covered with fascia taken either from the dorsum of the forearm or from the thigh

The condition of traumatic myositis ossificans must not be confused with the very rare condition known as myositis ossificans progressiva in which plaques of bone are laid down in the muscles of the back and chest

**Injury to Tendons** An immediate rupture of a tendon as a complication of a closed fracture is uncommon With open fractures a tendon may be divided by the external force which caused the fracture

The condition of delayed or late rupture of tendons is sometimes seen following a fracture it occurs particularly in connection with the extensor longus pollicis tendon following a Colles fracture The clinical course of the case is usually that of a Colles fracture which recovers normally, but some weeks later soon after vigorous use of the hand is commenced the long extensor of the thumb ruptures from some trivial injury The sequence of events is either that the tendon is partly divided when the fracture occurs or that it gets frayed and worn through as it slides in its rather narrow groove on the back of the radius which has become irregular as the result of the fracture

**Injury to Joints** A poor functional result following any fracture usually means that there is limitation of movement at one or more joints Limitation of movement may be due to irregularity of the articular surfaces if the fracture involves a joint to intra or peri-articular adhesions to muscles being adherent to a fracture at some distance from the joint to bony ankylosis following severe comminution of opposing

articular surfaces or later to osteo-arthritis The involvement of a joint by a fracture may be followed by a perfect functional result but a somewhat guarded prognosis as regards movement should always be given, good function depends mainly on exact reposition of the fragments When there is limitation of movement at a joint following a fracture a decision has always to be made as to whether the joint requires further rest or a manipulation to increase its movements In the first few weeks after a fracture in children and particularly in the elbow, rest is indicated and not forced passive movements at all ages rest even to the extent of complete immobilisation in plaster will sometimes cause an increase of movements at a joint rather than a diminution but every case of stiffness following a fracture must be judged individually and as far as possible the cause of the stiffness determined Particularly must stiffness due to muscle spasm which is a protective mechanism and requires rest be distinguished from adhesions which should be broken down

A joint which has been the site of a fracture is more likely to show osteo-arthritic changes at a later date than an uninjured joint

**Affections of the Skin** After severe fractures it is common to see large blisters on the limb They are called fracture blisters' and are seen when there is considerable tension in the underlying soft tissues Their presence should not deter one from reducing a fracture and putting it in a plaster cast The blisters should be cut away and the raw surface covered with a piece of gauze which has been soaked in a 2 per cent solution of tannic acid or powdered with sulphanilamide The plaster cast may be put on directly over this and when removed some days or weeks later the site of the blister will be completely healed

## Chapter VII

# DISLOCATIONS

Dislocations may be divided into

(1) Congenital
(2) Traumatic
(3) Pathological.

(1) Congenital dislocations most commonly seen in the hip joint form a subject outside the scope of this book

(2) Traumatic dislocations are of frequent occurrence The strength of joints depends on three things the surrounding muscles the ligaments and the shape of the articular surfaces of the bones The importance of these three varies in different joints in the shoulder for example, the muscles are the most important in the knee joint the ligaments are the main things preventing dislocation and in the hip it is largely the shape of the articular surfaces which makes dislocation uncommon The commonest joints at which dislocations are seen are the shoulder the elbow the inter phalangeal the metacarpo-phalangeal and the temporo-mandibular joints In the knee and wrist joints although the shape of the articular surfaces does not make for stability dislocations are rarely met with

In traumatic dislocations there is usually very great pain, often more than with a fracture (except when the latter is moved) but the degree of surgical shock is less The relief of pain after reduction of a dislocation is often quite dramatic With all traumatic dislocations it is most important to have good skiagrams preferably before and after reduction and of these the latter are the more important

A fracture of an adjacent fragment of bone often occurs in association with a dislocation the greater tuberosity at the upper end of the humerus the coronoid process of the ulna and the rim of the acetabulum being examples It is important to recognise a fracture in association with a

dislocation because it usually demands that immobilisation should be more prolonged and it also affects the prognosis. With certain dislocations it is not uncommon to find injuries to adjacent nerves they are usually only stretched or bruised and rarely torn through but the recognition of the lesion before reduction of the dislocation is important both for medico legal reasons as well as for its bearing on the after treatment

While the functional result after most dislocations is good it is wise to give a somewhat guarded prognosis especially in old people In the elbow and to a lesser degree elsewhere excessive peri articular bone formation may occur and will of necessity cause considerable limitation of movement This complication is likely to be aggravated by early vigorous movements of the joint passive movements and deep massage are contra indicated

(3) Pathological Dislocations Pathological disloca tions according to their cause may be divided into

(a) Dislocations due to destruction of bone
(b) Dislocations resulting from distension of a joint
(c) Dislocations secondary to muscular paralysis either flaccid or spastic

(a) Dislocations following destruction of bone are typic ally seen in tuberculous disease of the hip When the upper lip of the acetabulum is destroyed the head of the femur *also misshapen by disease readily but slowly slips out of* joint without the patient realising it

(b) Dislocation from distension of a joint is seen most commonly in suppurative arthritis When the joint is distended the ligaments and capsule become stretched and the articular surfaces readily slide apart without the patient being aware of it The same condition is also seen from distension of the joint with fluid in typhoid and scarlet fevers The treatment of such dislocations is mainly preven tive by splinting joints in such positions as to prevent dislocation, and if necessary maintaining light traction When the dislocation has occurred reduction is usually easy and should be carried out as soon as it is recognised

the steady pull of a weight attached to the leg will reduce the dislocation No anæsthetic is required

(c) Dislocation from paralysis of muscles occurs in the flaccid type from the unopposed pull of the antagonistic non paralysed groups of muscles In spastic paralysis dislocation results from the continuous and powerful pull of the muscles in one direction—*e.g*, in spastic paralysis *of the lower limbs with the hips in adduction and internal* rotation dislocation may result from the head of the femur slipping out of the posterior and upper part of the acetabulum The treatment of such conditions is difficult and is that of the spastic paralysis itself

## SPECIAL

### Chapter VIII

# FRACTURES AND DISLOCATIONS OF THE CLAVICLE

(a) Fractures of the Shaft
(b) Fractures of the Outer End
(c) Fractures of the Inner End

## (a) Fractures of the Shaft

The clavicle may be fractured by direct or indirect violence The latter is the commoner cause and the accident is in the nature of a fall on the outstretched hand or on the elbow or point of the shoulder The clavicle



Fig 11 Green-stick fracture of clavicle with characteristic angulation convex upwards. If union occurs with the fragments in this posit on there will be perfect function, but slight visible deformity The latter will disappear as the child grows.

usually breaks just to the outer side of its midpoint where the two curves of the bone meet A direct blow on the clavicle is a less common cause of fracture and, from the nature and direction of the violence there may be injury to the underlying vessels and brachial plexus In children green-stick fractures with little displacement are not un

common and may be overlooked in the absence of the usual signs and symptoms of fracture When displacement occurs in an adult it is characteristic The shoulder, with the outer fragment, is displaced downwards and forwards while the muscles between the thorax and humerus pull it inwards towards the middle line so that the fragments overlap The proximal fragment may be elevated by the pull of the sterno-mastoid muscle

Treatment In a child with a green stick fracture the arm should be well supported in a sling and bandaged firmly to the chest After three weeks the sling and bandage may be removed and no further treatment is necessary Any deformity the result of displacement or callus formation, gradually disappears as the child grows

In adults when there is no displacement a sling which supports the weight of the arm properly and is not simply an ornament is perfectly adequate treatment but in those cases where there is displacement some form of retentive apparatus is required. There are few fractures in the body for which so many different splints have been advised. This must indicate that none of them has been really satisfactory and it still remains for the perfect splint to be devised.

A fractured clavicle is easily reduced by pulling the shoulders backwards and raising the arm and any splint which is used must be so made that it holds the shoulder of the affected side in this position There are many modifications of the three-handkerchief method combined with a sling in use and this method is the simplest way of carrying out the essential points in splinting a fractured clavicle The main objection to its use is the discomfort caused by pressure on the front of the shoulder and in the axilla The several methods which necessitate the use of much adhesive strapping on the skin have in common the objection of being uncomfortable of causing soreness of the skin and of perhaps even producing a rash in addition, they do not efficiently hold the fracture in position.

When reducing a fractured clavicle a general anæsthetic is not only unnecessary but it is also most inconvenient as

it is very difficult to apply any form of splint to the shoulder girdle with a patient unconscious and lying down. A local anæsthetic in the form of ten cubic centimetres of a 2 per cent solution of novocain injected into the hæmatoma at the site of fracture with a fine needle is of great comfort to the patient and of assistance to the surgeon as it obliterates any muscle spasm caused by the pain of manipulation. The displacement is then reduced by elevating and pulling the shoulder backwards The most effective method of splinting for general use is a modification of the three handkerchief technique Two sausage-like tubes of firm smooth flannel bandage are prepared and well padded with wool or soft felt An assistant supports the arm at the elbow the surgeon takes each sausage and lays it vertically in front of each shoulder The ends of the flannel bandage have been left long and these are taken through the axillæ and over the top of the shoulders and sewn together behind each shoulder so that a ring is formed. The surgeon pulls the shoulders back and a third assistant sews the loose ends of bandage from the two shoulders firmly together, so that the join lies between the scapulæ The support is continued by a firm flannel bandage applied in a figure-of eight manner from behind, forwards with the cross-over between the shoulder blades Finally the weight of the arm is taken by an ordinary sling applied as in the first aid text books for a fractured collar bone The sausages must be well padded and firm. The firmer they are the less likely are they to cause pressure in the axillæ with consequent venous and lymphatic obstruction. This method holds a fractured clavicle well reduced but however carefully it is used, pressure sores are liable to develop in a few cases and all likely places must be carefully watched and the skin powdered. The sling bandages and rings should be inspected and adjusted daily for the first week and will then be reasonably comfortable From the first the patient should be encouraged to brace the shoulders and to flex and extend the elbow regularly In this injury as in the early stages of all shoulder injuries the sleeve should not be used and the clothing should be worn over

the sling but it is very important that the patient should be encouraged to expose and to use his hand Exercises for the shoulder and whole limb are begun as soon as the fracture is united

A fracture of the clavicle unites readily and usually in about three weeks A sufficiency of callus is quickly formed and non union is rare but in many cases mal union occurs No splint holds the fragments of a fractured clavicle in perfect position unless it is put on so tightly as to be uncomfortable the result is that in the majority of cases the fracture unites with some displacement Functionally this is of no consequence whatever, its only disadvantage being the presence of an unsightly lump on the clavicle If union has taken place with a fragment of bone projecting unpleasantly under the skin it may be exposed by operation and the prominent fragment smoothed off

A method of treatment which is sometimes advised but rarely carried out is that of keeping the patient in bed lying flat on his back for three weeks with a small sand bag between the shoulders When lying in this position the fragments of the fracture take up an almost perfect position and union without deformity may be expected

## (b) Fractures of the Outer End of the Clavicle

Fracture at the outer end of the clavicle sometimes occurs from a fall on the shoulder though a dislocation of the acromio-clavicular joint is more common Gross displacement is rare because the fracture is situated on the outer side of the ligaments joining the clavicle to the coracoid process of the scapula which thus hold the main inner fragment in position The outer fragment is held to the acromion by the superior and inferior acromio-clavicular ligaments Diagnosis without an X ray examination is not easy though a fracture may be suspected from the local tenderness

**Treatment** Disability from this fracture is uncommon, and unless there is displacement no treatment other than a sling under the arm for ten to fourteen days is necessary One

patient having bi lateral fractures of the clavicles of this type continued at his ordinary clerical work for ten days before asking advice as to the cause of his continued pain. The pain was so slight and there was so little disability that treatment was unnecessary If there is displacement with a fracture at the outer end of the clavicle it is immobilised as for a dislocation of the acromio-clavicular joint

### (c) Fractures of the Inner End of the Clavicle

This is the rarest position in the bone for a fracture Small inner fragments are difficult to control, and if they are angulated forwards or upwards an attempt should be made to push them back into position If this is possible the arm should be treated as for a fracture of the shaft of the clavicle If by manipulation a satisfactory position cannot be obtained then an open operation may be called for and the fragments are sutured together with catgut or fascia lata

## Dislocations of the Clavicle

The clavicle may be dislocated at either end but an acromio-clavicular dislocation is much commoner than one at the sternal end

Acromio-Clavicular Dislocations These usually result from a fall on the shoulder The clavicle is always displaced upwards in relation to the acromion. It is commoner to find a subluxation with slight displacement than a dislocation, and in these cases the ligaments are only stretched or partly torn. When there is a complete separation of the articular surfaces of the joint the conoid and trapezoid ligaments joining the clavicle to the coracoid process are torn.

**Treatment** To put the arm in a sling is not sufficient since the clavicle must be held down as the shoulder is pushed up A pad of adhesive felt or of several layers of adhesive strapping sticky side outwards is stuck to the skin over the outer end of the clavicle a strip of two-inch adhesive strapping passes over this above and below passes under the upper end of the ulna the elbow being flexed. If

this band of strapping is put on properly and firmly, it holds the arm up as it holds the clavicle down The wrist is supported from the neck by a narrow sling It is advisable to keep this strapping on for six weeks in a dislocation and three weeks in a subluxation after this the patient should use the arm carefully and abstain from vigorous games for some months as it is an injury which is likely to recur



FIG 12. Dislocation at the acromio-clavicular joint. The clavicle is displaced upwards in relation to the acromion process in the characteristic manner Reduction is obtained by raising the shoulder while the clavicle is depressed.

The functional results are usually good although in many cases there is some residual deformity

A few patients have persistent deformity and for them an operation may be advisable A variety of operations has been carried out some on the acromio-clavicular joint and others for reconstructing the coraco-clavicular ligaments the latter is the best type of operation Fascia lata may be used to replace the ligaments and to hold the clavicle down in position However the most common cause of disablement after this injury is not from gross displacement but from a traumatic arthritis of the acromio-clavicular joint

when there has been severe subluxation rather than complete dislocation In these cases pain may be so severe that an operation for resection of the outer one inch of the clavicle is justified and the results of this method of treatment are very satisfactory

Dislocations of the Sterno-clavicular Joint These are uncommon They may result from a fall on the shoulder, from a direct blow on the inner end of the clavicle and occasionally from a trivial strain as when reaching up with the arm above the head. The displacement of the clavicle is usually forward except in those cases resulting from direct violence in which backward displacement results, and in severe cases the great vessels behind it and even the trachea may be compressed.

**Treatment** For the ordinary forward dislocation no simple method will hold the bone securely back in position It is usually easy in a recent case to push the clavicle back wards so that it articulates properly with the sternum but as soon as the shoulder is moved at all the clavicle comes forward with great force In each case a trial must be made to see in what position the dislocation remains reduced. It will often be found that with the shoulder held well up with a high sling under the elbow the clavicle remains in position. This should be combined with a pad over the inner end of the bone held securely by long strips of adhesive strapping The arm should be immobilised for six weeks In resistant cases associated with pain it is sometimes necessary to perform an open operation and fix the clavicle down in position, either to the first rib or to the sternum Fascia lata may be used for this purpose

## Chapter IX

# FRACTURES OF THE SCAPULA

Fractures of the scapula are relatively uncommon, and except for those involving the glenoid cavity and those through the neck of the bone are relatively unimportant

Glenoid Cavity The lower margin of the articular surface of the glenoid may be fractured in conjunction with a dislocation of the shoulder joint, and if union does not occur in good position a recurrent dislocation of the joint may result When associated with a dislocation this fracture is only recognised by X ray examination or by feeling crepitus as the dislocation is reduced

Neck of Scapula A fracture through the neck of the scapula allows the glenoid cavity with the humerus to be displaced downwards and this fracture clinically may simulate a dislocation of the shoulder as on examination a gap is felt below the acromion process the head of the humerus being displaced downwards this gives the impression of the head having slipped out of the glenoid cavity instead of being displaced downwards with it An X ray examination will make the diagnosis clear but the condition should be suspected if with the head of the humerus displaced downwards the arm is close to the side instead of abducted as it is with a dislocation

Body of Scapula Fractures through the body of the scapula may involve the supra or infra-spinous fossa or the spine of the scapula There is usually not much displacement the muscles surrounding the bone holding the fragments in position. Often if there is displacement most easily seen on the axillary border reduction is not possible by manipulation nor is it necessary

**Treatment** For fractures involving the glenoid cavity or neck of the scapula it is best to treat the arm on a shoulder abduction splint After two weeks gentle active movements without removing the splint may be begun and the splint

may be removed after four weeks and active movements continued

For fractures involving other parts of the scapula the latter should be strapped as securely to the chest as possible and the arm carried in a sling for three weeks It is impossible to limit movement of the scapula completely but the strapping gives comforting support

## Chapter X

# DISLOCATIONS OF THE SHOULDER

The shoulder is one of the commonest joints in the body to be dislocated This is due to the shallowness of the glenoid cavity and the insufficiency of strong ligaments The joint depends mainly on the surrounding muscles for its strength Of the four classical dislocations—subcoracoid, subspinous, subclavicular and subglenoid—the first is much the commonest There is a rare variety of the subglenoid type in which the shoulder is dislocated with the arm fixed straight up above the head—luxatio erecta

In the common subcoracoid dislocation there is a gap below the acromion process where the head of the humerus is normally palpable when dislocated the head can be felt below the coracoid process The arm is usually a little abducted from the side and there is great pain and inability to move the shoulder, the diagnosis is usually obvious and can only be confused with a fracture of the neck of the scapula Associated nerve injuries are not uncommon the circumflex (axillary) nerve which supplies the deltoid is that most commonly involved Next in frequency are injuries to either the inner cord of the brachial plexus or to the ulnar nerve itself It is wise always to test for any nerve injury before reduction of the dislocation Associated fractures are not uncommon the most frequent being a fracture of the greater tuberosity but fractures of the neck of the humerus or of the glenoid cavity of the scapula may also occur and may not be detected until an X ray examination is made though crepitus may be felt while reducing the dislocation and with an associated fracture of the glenoid it may be observed that dislocation recurs immediately after reduction

Treatment The sooner a dislocation is reduced the better If seen within a few moments of the accident it is often possible to put the shoulder back without an anæs-

thetic, otherwise an anæsthetic is necessary Unless there appears to be something unusual about the case, it is sound



Fig 13 Dislocation of the shoulder joint The head of the humerus is in the subcoracoid position below the coracoid process. The head of the humerus being displaced medially the acromion process projects prominently and gives a square appearance to the shoulder

treatment to reduce the dislocation without waiting for an X ray An X ray examination should always be made after reduction to exclude the presence of a fracture as well as to see that reduction is satisfactory

Many methods have been described for reducing a dislo-

cated shoulder each has its merits and some have their drawbacks The well known "Kocher s" method works well in most cases, and it does not require the help of an assistant. The method may briefly be described as follows

The surgeon grasps the patient s elbow with one hand and the patient s wrist with his other holding the elbow at a right angle The first movement is to adduct the elbow to the side The second movement consists in externally rotating the shoulder by bringing the hand away from the body while the elbow is kept to the side The arm should be held in full external rotation for a little time in order to tire out the subscapularis muscle In the third movement while still holding the shoulder externally rotated and the elbow at a right angle the arm is adducted further by bringing the elbow across in front of the upper part of the abdomen as far as possible as this is done the head of the humerus is sometimes felt to slip back into its socket, if it does not this will be felt to happen during the fourth movement which consists of internal rotation of the shoulder joint by bringing the hand across the body In some subjects particularly if they are very fat or muscular this method of reducing a dislocated shoulder may fail should this happen, the following may then be used but has the disadvantage that at least one assistant is required With the patient anaesthetised and lying on his back, the arm is fully abducted to a position of 90 degrees from the trunk holding the patient s wrist traction is made on the arm while an assistant makes counter traction by holding the blade of the scapula firmly against the trunk. If there is deep anaesthesia—and this is essential for reducing a difficult dislocation of the shoulder—the muscles will be felt to give as traction is made When this is felt the arm is gradually brought down to the side traction being maintained Reduction will usually occur readily but can be assisted by rotating the arm and by pressure against the head of the humerus in the axilla After reduction has been obtained by either method the arm should be bandaged to the side and carried in a sling for ten days and then active movements begun.

The shoulder is one of the commonest joints in which to see recurrent or habitual dislocation. Attempts should be made to cure the condition by instructing the patient to avoid carelessly abducting the arm and doing other movements which he finds causes the dislocation If dislocation can be avoided for some months it becomes less liable to occur and may disappear completely In others no improvement takes place and an operation becomes necessary Many operations have been devised for this condition, but the best is either that described by Nicola or that of Bankart In the former the long head of the biceps is divided, threaded through a hole bored in the head of the humerus and united again Bankart says that recurrent dislocation is always due to detachment of the glenoid ligament from the anterior margin of the glenoid cavity this defect is repaired at operation

When a fracture is associated with a dislocation of the shoulder the treatment differs somewhat If it is known that a fracture is present the traction in abduction method of reduction should be used, reduction being completed by pushing the head of the humerus up in the axilla If there is a fracture of the greater tuberosity with displacement the arm must be treated in abduction active movements of the shoulder are begun after three weeks Stiffness in the fingers wrist and elbow is prevented by encouraging movements in these joints from the beginning For special treatment of fractures of the greater tuberosity see page 104.

If there is a fracture of the neck of the humerus, reduction of the dislocation is sometimes difficult but it must always take precedence over the fracture and under no circumstances should the fracture be allowed to unite with the hope of reducing the dislocation at a later date If reduction cannot be brought about by powerful traction on the arm abducted to a right angle and pushing the head up in the axilla the advisability of doing an open operation may have to be considered. The joint is exposed by an anterior incision and if the fracture and the dislocation can both be satisfactorily reduced the wound is closed and the arm treated on a shoulder abduction splint passive movements

commencing at the end of a week Occasionally a satisfactory reduction is impossible

When there is an associated nerve injury expectant treatment is carried out The nerve injury is usually the result of stretching of, or pressure on the nerve, and is not due to a division of it With a circumflex (axillary) nerve palsy the arm must be kept in abduction until the deltoid muscle has reached a fair state of recovery With an ulnar nerve injury massage and movements must be carried out to prevent contractions of the fingers while with a musculo-spiral paralysis a cock up splint must be used to prevent wrist-drop

UNREDUCED DISLOCATIONS OF THE SHOULDER. It is impossible to give an exact time after which an attempt should not be made to reduce an unreduced dislocation. In the ordinary subcoracoid dislocation the head of the humerus has come out of the capsule and lies immediately under the axillary artery and vein to which after a few weeks it becomes closely adherent If after some time vigorous attempts at reduction are carried out the axillary vein may be torn and nerves injured. Two months is about the limit after which a manipulative reduction is unsafe

For an unreduced dislocation seen late a gentle attempt at reduction may be tried but will probably fail. There are then two courses open if the patient is beyond middle age and particularly if he is stout it is often best to continue conservative treatment unless pain is present In young subjects and in older ones who have persistent pain an open operation should be carried out By an anterior approach the shoulder joint is exposed and an attempt made to reduce the dislocation. There is usually a large amount of new fibrous tissue round the bones and filling up the glenoid cavity and reduction is often difficult or even impossible The severely painful old unreduced dislocation of the shoulder is best treated by arthrodesis

## Chapter XI

# FRACTURES OF THE HUMERUS

**(1) Fractures of the Upper End**

(a) Fractures of the Neck
(b) Fracture of the Greater Tuberosity
(c) Separation of the Epiphysis

**(2) Fractures of the Shaft**

**(3) Fractures of the Lower End**

(a) Supra-condylar Fracture
(b) Separation of the Epiphysis
(c) Condylar Inter-condylar and T shaped Fractures
(d) Fractures of the Epicondyles

## (1) Fractures of the Upper End of the Humerus

(a) Fractures of the Neck An anatomical and a surgical neck of the humerus are described by anatomists but when considering fractures it is confusing to attempt to differentiate sharply between the two The site of many fractures is such that it is not possible to say that any given fracture is at the surgical or anatomical neck, because probably it is not exactly at either

They may result from direct or indirect injury and are common at all ages over ten. The pain tenderness disability *and later the swelling usually suggest the* diagnosis but being hidden under the deltoid muscle the exact level and type of fracture is not easy to gauge except by X ray examination. Sometimes when there is impaction the symptoms are very slight and without an X ray the fracture may be overlooked

Of the fractures in the lower part of the neck, the majority show practically no displacement although a number of them are impacted in a few there is lateral displacement

with overlapping, the distal fragment more often lying on the medial side of the proximal

In the upper part of the neck there is but little displacement in most cases and impaction is frequently present With a few however there is considerable displacement the upper end of the shaft lies below the shoulder joint, medial to the head of the humerus and often anterior, the head is



Fig 14 Fracture of the neck of the humerus. An abduction fracture with some impaction but only slight displacement.

abducted so that the fractured surface faces laterally and sometimes forwards to a certain degree in some cases the articular surfaces of the humerus and glenoid are not in contact (Fig 15)

*Fractures* of the neck of the humerus have been divided into those due to abduction and those to adduction and in a certain number of cases the displacement, though it may be negligible from the point of view requiring correction will

locked in a satisfactory position the arm is placed on a shoulder abduction splint Gentle controlled active movements are begun in three weeks and the splint removed at the end of five weeks This manœuvre for reduction is not always successful and in a number of cases an X ray examination after manipulation shows an unsatisfactory position another attempt at reduction by manipulation should then be made and instead of that just described success may be obtained if traction is made on the arm while it is *adducted* across the body anteriorly and then brought back to the side This sometimes brings the fractured surfaces of bone together when the abduction method has failed

If all methods of reduction by manipulation have failed there are two courses open The first is to leave the bones in the unsatisfactory position, and in young patients provided there is no angulation but only overlapping a surprisingly good functional result will occur and with the fullness of the deltoid muscle covering the site of fracture the deformity is hardly noticed The second course is to reduce the displacement by open operation The fracture is exposed by an anterior incision and the fragments levered into position the arm is then put up on an abduction splint

Except in old persons the results of fractures of the surgical neck of the humerus are good and provided the position of the fragments is not really bad, open operation for reduction is seldom indicated.

(*b*) Fracture of the Greater Tuberosity The greater tuberosity is fractured as the result of direct violence, or of indirect violence in conjunction with a dislocation of the shoulder In the former case there is usually little separation of the fragment but in the latter the tuberosity remains attached to tendons and the ligaments of the joint and thus becomes separated some distance from the head of the humerus which is displaced downwards and forwards (*cf* page 98) The supra-spinatus tendon being attached to the greater tuberosity tends to draw this fragment up

Treatment In all cases in which the detached fragment remains displaced after the dislocation has been reduced

it is best to treat the shoulder in abduction for by this means the greater tuberosity is more likely to be in its correct position In those cases where there is no displacement the arm is immobilised in a sling and bandaged to the side for two weeks and active movements are then begun

When the fracture is the result of direct violence there seems in many cases little tendency for the tuberosity to become displaced as movements are carried out the ligaments capsule and tendon attachments anchor it in position In one case a medical man continued at his ordinary work without treatment and although in pain was able to take down bottles from shelves while dispensing indeed in this case the fracture was not diagnosed until he had the shoulder X rayed more than a fortnight after the injury the function was then so good that no treatment was advised

(c) Separation of the Epiphysis By separation of the epiphysis of the upper end of the humerus is meant the separation of the whole head composed of the three epiphyses the head the greater tuberosity and the lesser tuberosity from the shaft This is not a common injury, and the displacement when present is variable The classical deformity is similar to that seen in fracture through the surgical neck where the head of the bone is abducted and externally rotated Where there is displacement an attempt should be made to correct it by abducting and externally rotating the arm while traction is made If good position is obtained as shown by an X ray examination the arm is bandaged to the side and the hand and forearm supported in a sling for three weeks wrist and finger movements are *encouraged from the beginning* If satisfactory position cannot be obtained except in abduction then the arm should be treated on a shoulder abduction splint for three weeks The functional results are good and there is seldom any interference with growth of the bone

## (2) Fractures of the Shaft of the Humerus

Fracture of the shaft of the humerus may result from direct or indirect violence It has been known to follow

locked in a satisfactory position the arm is placed on a shoulder abduction splint Gentle controlled active movements are begun in three weeks and the splint removed at the end of five weeks This manœuvre for reduction is not always successful and in a number of cases an X ray examination after manipulation shows an unsatisfactory position another attempt at reduction by manipulation should then be made and instead of that just described, success may be obtained if traction is made on the arm while it is *adducted* across the body anteriorly and then brought back to the side This sometimes brings the fractured surfaces of bone together when the abduction method has failed.

If all methods of reduction by manipulation have failed there are two courses open The first is to leave the bones in the unsatisfactory position and in young patients provided there is no angulation but only overlapping a surprisingly good functional result will occur and with the fullness of the deltoid muscle covering the site of fracture the deformity is hardly noticed The second course is to reduce the displacement by open operation The fracture is exposed by an anterior incision and the fragments levered into position the arm is then put up on an abduction splint

Except in old persons the results of fractures of the surgical neck of the humerus are good, and provided the position of the fragments is not really bad open operation for reduction is seldom indicated

(*b*) Fracture of the Greater Tuberosity The greater tuberosity is fractured as the result of direct violence or of indirect violence in conjunction with a dislocation of the shoulder In the former case there is usually little separation of the fragment but in the latter the tuberosity remains attached to tendons and the ligaments of the joint and thus becomes separated some distance from the head of the humerus which is displaced downwards and forwards (*cf* page 98) The supra spinatus tendon, being attached to the greater tuberosity tends to draw this fragment up

**Treatment** In all cases in which the detached fragment remains displaced after the dislocation has been reduced





FIG 16 "Horse shoe" plaster for fracture of the shaft of the humerus.

almost always secure adequate reduction of the fracture The position should be checked at once by X ray and the manœuvre repeated if the position is not satisfactory

muscular effort as in throwing a ball. Transverse, oblique and comminuted fractures occur The displacement is variable and to a certain extent depends on the level at which the fracture occurs With fractures in the upper half of the bone—that is, above the insertion of the deltoid—the upper fragment is usually adducted the distal fragment overlapping it on its outer side With fractures below the insertion of the deltoid, the proximal fragment is abducted by that muscle so that it lies on the outer side of the distal fragment With all fractures of the shaft of the humerus, but particularly with those of the middle of the bone evidence of injury to the radial nerve should be looked for In actual practice this nerve is not injured as often as might be expected

The shaft of the humerus is one of the sites in the body where delayed or non union is liable to occur so that a somewhat guarded prognosis should be given as regards period of disablement

**Treatment** It is surprising how easily fractures of the shaft of the humerus may be reduced by a relatively simple procedure and the older methods of continuous extension on an abduction splint or Thomas s arm splint are very seldom necessary

It is not essential to obtain exact end to end apposition of the fractured surfaces and if angulation and over lengthening are studiously avoided a good side to side apposition with not more than one-half inch of shortening will give an excellent functional result

The site of fracture is anæsthetised by local injection or by a brachial plexus block and the patient is persuaded to sit up A small pad of felt is placed over the top of the shoulder and across the upper end of the inner surface of the arm and a plaster of Paris slab is moulded from the shoulder down over the outer surface of the arm round the elbow and up on the inner surface of the arm to the axilla the slab is rapidly secured with a single plaster bandage The elbow is kept at a right angle and a little gentle traction on the long axis of the arm with the arm adducted to the side combined with moulding of the shaft of the humerus will

fractured surfaces are not in contact In all supra-condylar fractures injuries to surrounding structures especially nerves should be looked for as ulnar median or musculo-spiral nerves may be involved In severe cases the pointed anterior surface of the lower end of the proximal fragment may project through the skin on the front of the elbow

Treatment The early recognition and proper treatment of a supra-condylar fracture will, in the majority of cases give an excellent result but if the injury is mismanaged treatment will be very prolonged and may be followed by permanent disability With much swelling it may be impossible to make a certain diagnosis but every such case should be X rayed As soon as the fracture is diagnosed it should be reduced nothing will be gained by delay for reduction actually becomes more difficult as each day passes and an accurate replacement of the fragments usually persuades the swelling to decrease more rapidly



FIG 17 Supra-condylar fracture of the lower end of the humerus. There is slight backward displacement of the distal fragment the displacement being in the form of angulation (convexity anterior) This is easy to correct by manipulation.

Where there is not sufficient displacement to require reduction the arm is immobilised by suspending the wrist in a collar and cuff sling with the elbow at an angle of about 80 degrees

In those fractures in which there is simple angulation of the fragments without separation of the fractured surfaces reduction is easily carried out by gripping the lower part of

The wrist is then supported in a sling and the whole arm bandaged to the side

Reduction may be more difficult if the patient is unable to sit up and this is one of the fractures in which a local anæsthetic is of great value During the first two weeks of immobilisation the patient should be persuaded to sleep propped up on pillows rather than lying down as the continuous effect of gravity is thus used to prevent redisplacement of the fracture

Immobilisation must be continued for at least six weeks At the end of this period the plaster should be removed and if the fracture is not by then showing signs of firm union immobilisation should be continued in a plaster shoulder spica Only by great care at this stage can delayed union or even non union be avoided

In a certain number of cases it is not possible to obtain a satisfactory position and an open operation for reduction and fixation of the fragments may be necessary

### (3) Fractures of the Lower End of the Humerus

(*a*) Supra-condylar. Supra condylar fractures are the commonest at the lower end of the humerus and are usually seen in children The history is that of a fall on the outstretched hand the elbow being slightly bent an injury which in adults causes a posterior dislocation of the elbow From the direction of the force a backward displacement of the distal fragment of the humerus occurs This is spoken of as the extension type and must be distinguished from the much less common flexion fracture in which there is a forward displacement of the distal fragment the result of a fall on the elbow

In the commoner extension type the line of fracture is not usually transverse but obliquely downwards and forwards The distal fragment is displaced backwards as the result of the fracturing force but this displacement is maintained by the pull of the triceps muscle The displacement may take the form of angulation (convexity anterior) the two fragments being in contact or of complete backward displacement so that the fragments are overlapping and the

taining this pull the elbow is flexed as advised by Böhler, the forearm should be pronated during the manipulation After reduction the elbow is immobilised by a plaster of Paris slab which reaches from the shoulder to the heads of the metacarpals with the elbow at a right angle and the forearm pronated, though not fully The cast may be put on next to the skin or over a thin even layer of wool

Supra-condylar fractures in which there has been little or no displacement should be immobilised for three weeks, but in the more severe cases four weeks immobilisation is advisable. After this for one week, movements are allowed in the collar-and-cuff sling which holds the elbow at a right angle and the patient is made to flex the arm as far as possible but only to extend it to a right angle as allowed by the sling At the end of four weeks in mild cases and five weeks in severe ones full active movements may be begun. If the patient is a child the arm should be carefully used. *All passive movements* should be avoided Physical treatment should not be allowed As was pointed out many years ago great harm may be done to elbow injuries particularly in children by forced physical movements and vigorous massage In many cases they will actually delay recovery and diminish the range of movements, and cannot be too strongly deprecated Within a few weeks of beginning active movements a wide range of flexion and extension should be possible If a good reduction has been easily obtained the prognosis as regards both strength and movements of the elbow is very good

It must be remembered that this is the injury following which Volkmann s contracture is prone to occur Damage to the brachial artery or its main branch may have occurred during manipulative reduction of a supra-condylar fracture so therefore the surgeon must always feel the radial pulse after he manipulates and again after the collar and cuff sling has been applied After this the limb must be constantly and carefully watched for any evidence of diminishing circulation and for increasing swelling of the limb with congestion of the main vein Swelling and congestion can be relieved by decreasing the amount of

the arm with the two hands one on either side while the thumbs press the distal fragment and olecranon process forwards If there is no great tendency for re-displacement to occur the arm may be immobilised by a collar and-cuff sling

Where there is a complete backward displacement with



Fig 18 Fig 19

Figs 18 and 19 Supra-condylar fracture of the lower end of the humerus. There is great displacement. In the antero-posterior view the distal fragment is displaced a distance equal to the whole thickness of the bone. In the lateral view it is seen to be displaced, so that it lies completely behind the shaft.

overlapping of the fragments the manœuvre described above is not likely to effect a reduction. Under a full general anæsthetic with an assistant making firm counter traction by holding the upper arm a strong pull is made on the fore-arm with the elbow in full extension This should be continued for a few minutes to overcome the pull of the muscles and to separate the fragments While still main

epiphysis X rays show that the epiphysis is displaced not only forwards but outwards so that it lies actually to the outer side of the radio-humeral joint When X rays of these cases are closely examined or when the fragment is seen at an operation it is found that the epiphysis has been rotated so that it is looking somewhat backwards It remains attached on its outer side and by swinging round as on a hinge becomes displaced forwards and outwards

A backward displacement of the main epiphysis is uncommon

A separation of the epiphysis of either the internal or external epicondyles may occur and is similar to the separation of the epicondyles in the adult



FIG 20 Separation of the distal epiphysis of the humerus. The displacement is outwards and forwards, the fragment reaching this position by rotating through an angle of 180 degrees. A fragment of the metaphysis can be seen adherent to the epiphysis.

Treatment A mild degree of forward displacement of the epiphysis especially when the deformity is mainly angulation, can in most cases be corrected by pressing on the epiphysis in front of the joint while the elbow is extended If reduction is successful the elbow should be carefully flexed again to a right angle and immobilised for three weeks in a plaster cast extending from the shoulder to the heads of the metacarpals

Where the epiphysis is displaced far forwards or where it is rotated forwards and outwards it may be impossible to obtain adequate reduction by manipulation In such cases an open operation should be performed and the

flexion at the elbow, but actual interference with the arterial circulation may well require the more serious measures which have already been described under Volkmann's Contracture (p 77)

In those cases in which it has not been possible to obtain a satisfactory position by manipulation open reduction will be necessary The fracture may be approached by a mid line posterior incision splitting the triceps or by a medial incision just anterior to the medial epicondyle the muscles arising from the latter are detached and by keeping close to the bone the fracture is easily reached The fragments may remain in position after being reduced though sometimes internal fixation is unnecessary

(*b*) Separation of the Epiphysis There are four epiphyses at the lower end of the humerus The first to appear and the most important is that for the capitellum and outer half of the trochlea This begins to ossify towards the end of the second year The epiphysis for the internal epicondyle appears in the fourth year and that for the remain ing part of the trochlear about the eleventh or twelfth year while the little epiphysis for the external epicondyle appears about the thirteenth year The epiphysis for the capitellum is the largest and has a characteristic somewhat triangular shape as seen in an antero posterior X ray In the lateral view it appears somewhat rounded and is placed slightly in front of the long axis of the humerus When speaking of a separation of the epiphysis of the lower end of the humerus it is to this one that reference is made unless otherwise stated As with most traumatic separations of *epiphyses the actual separation does not occur through* the epiphyseal line but through the diaphysis close to the line and an X ray usually shows a thin flake of the diaphysis with the separated epiphysis A separation of the epiphysis at the lower end of the humerus is usually a flexion injury the force coming from behind as with a fall on the elbow and the epiphysis with the flake of diaphysis is displaced forwards

In children about the age of five or six there is another classical and not very uncommon displacement of the

heading A vertical fracture between the condyles without displacement of either and reaching the joint below, may occur if this is combined with a supra-condylar fracture, a T-shaped fracture results With this there may be little displacement though at times the two fragments may be widely separated from each other and from the shaft Either condyle alone may be separated the line of fracture being variable but often running obliquely upwards and inwards, or upwards and outwards from about the middle of the articular surface below to the inner or outer surface of the humerus above With those cases where there is no appreciable displacement the arm may be immobilised in a plaster cast reaching from the shoulder to the heads of the metacarpals with the elbow at a right angle This may be removed after four weeks but during that time the patient is encouraged to use the shoulder and fingers as much as possible When the plaster is removed active movements of the forearm are begun but for a fortnight the forearm should be supported in a sling for the greater part of the day

Where there is displacement with any of these fractures an attempt must be made to manipulate the fragments into position this is best done by making traction on the forearm in the long axis of the humerus with the elbow at a right angle If this fails there are two alternatives either to do an open operation and fix the fragments together or to apply continuous traction the latter is best done by means of a Kirschner wire passed through the olecranon process of the ulna By open operation it is not always easy to reduce and fix the fragments satisfactorily A triradiate plate has often been used for T-shaped fractures but it is best if possible to avoid using metal in any form and it is preferable to stitch the periosteum with catgut or if this cannot be done to bore small holes in the fragments and suture them together with catgut after this immobilisation in a plaster cast for five or six weeks should be carried out If continuous traction is employed the fragments will be united sufficiently by soft callus after three weeks to allow the arm to be put in plaster the latter is kept on for another two weeks

epiphysis exposed and if possible replaced in its correct position. The epiphysis can often be felt under the skin on the outer side and the best incision is one directly over it in this position care must be taken to avoid the musculo-spiral nerve *After reduction the arm should be immobilised for three weeks in plaster*

After treatment should consist of active movements alone and the previous remarks about restraint and discretion in the use of passive movements and massage in the treatment of supra condylar fractures apply with even greater em phasis to separation of the epiphysis



FIG 21 T-shaped fracture of the lower end of the humerus with internal displacement. The portions of the humerus which articulate with the radius and ulna are separated from each other

If a satisfactory reduction of a displaced epiphysis has been obtained *the functional* result is almost per fect in most cases and there is no inter ference with growth of the bone but with an unsatisfactory reduction the carrying angle may be altered and a cubitus valgus or varus may result if this appears an osteotomy may be required at a later date The cubitus valgus may be the cause of a late ulnar neuritis (see page 73)

(c) CONDYLAR INTER *CONDYLAR AND* T SHAPED FRACTURES A great variety of frac tures come under this

reducing the dislocation to sweep the separated fragment of bone out the way and thus perhaps avoid the necessity of an open operation With internal epicondyle fractures an ulnar nerve lesion is likely to be present The nerve may be stretched or bruised and is only rarely torn If an open



*Fig 92* *Separation of the internal epicondyle of the humerus* with displacement of the separated fragment into the elbow joint The ligaments on the internal side of the joint are torn and there is a cubitus valgus deformity The flexor tendons remain attached to the internal epicondyle and at operation can be seen emerging from the joint.

operation for fixation of the internal epicondyle is indicated it is wise to expose the ulnar nerve and place it in a new bed anterior to the internal epicondyle

With severe fractures of the condyles there is usually some permanent limitation of movement both in flexion and extension This limitation is partly due to adhesions but also largely due to an actual bony block caused by misplaced fragments of bone or by a mass of bone filling up the olecranon and coronoid fossæ of the humerus If the patient is young the range of movements gradually increases with time and an almost full range of movement is obtained when the displacement has not been great

If the carrying angle has increased during the reduction and immobilisation a late ulnar neuritis may come on. This is especially likely to occur in fractures of the outer condyle and it is better to have a straight arm with a carrying angle lost than to have a carrying angle increased.

(*d*) Fractures of the Epicondyles The internal epicondyle is fractured more commonly than the external. By a direct blow it is separated but in the majority of cases there is but little displacement In some however it may be displaced into the joint and this may even occur when there is no dislocation the internal epicondyle with the origin of the flexor muscles lying in the joint between the humerus and the ulna Whether dislocation is present or not with this peculiar displacement the internal lateral ligament of the elbow joint is torn through allowing the inner side of the joint to open out

Treatment With a fracture of the internal or external epicondyles without displacement the elbow should be immobilised for two weeks in a collar and cuff sling with the elbow at a little less than a right angle

Where the internal epicondyle is displaced a decision must be made as to whether an open operation is required If the displacement is not great perfect function will result by leaving the internal epicondyle to unite by fibrous tissue but with considerable displacement and in those cases where the internal epicondyle is lying in the joint an open operation must be performed and the separated fragment either sutured back into position with catgut or fixed by a small bone graft In cases where the internal epicondyle lies in the joint in association with a dislocation it is sometimes possible when

fracture of the humerus A lateral displacement of the radius and ulna together is the next commonest variety It is rare to find a forward dislocation of both bones but a forward displacement of the radius associated with a fracture



FIG 24 Dislocation of the elbow joint. The radius and ulna attached together are displaced laterally in relation to the humerus.

about the junction of the upper and middle thirds of the ulna is a classical and not rare injury (Fig 25)

The diagnosis is usually easy if the relation of the bony points around the elbow is carefully examined In the case of a supra-condylar fracture the internal and external epicondyles and the olecranon process will bear their normal relation to each other but with a backward dislocation the

## CHAPTER XII

# DISLOCATIONS OF THE ELBOW

THE commonest dislocation of the elbow is a backward displacement of both bones of the forearm in relation to the humerus. This injury often results from a fall on the outstretched hand with the elbow slightly bent. In a child this type of accident is more likely to cause a supra-condylar



FIG. 23. Dislocation of the elbow joint. The radius and ulna remain attached together and are displaced posteriorly in relation to the humerus. Some small fragments of bone are seen. These are very commonly present in this type of dislocation.

readily recurs due to a fracture of the coronoid process it may be necessary to immobilise the elbow in a plaster of Paris cast which extends from the shoulder to the heads of the metacarpals When the coronoid process is fractured movements should not be commenced for four weeks but with a slight fracture of the head of the radius complete fixation for two to three weeks is usually sufficient In some fracture-dislocations of the elbow an X ray examination will

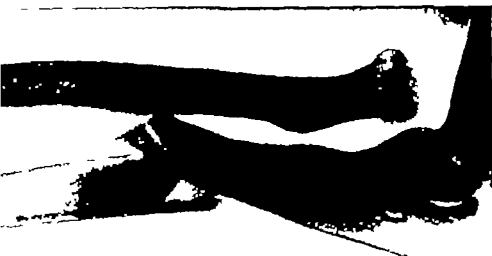


FIG 25 Dislocation of the radius (Monteggia fracture) The head of the radius is displaced forwards in relation to the humerus, the orbicular ligament surrounding it being torn The shaft of the ulna is fractured with angulation anteriorly In this classical lesion the displacement of the radius is sometimes overlooked with disastrous results to the movements of the joint.

show a number of chips of bone the origin of which cannot certainly be determined If these seem to be in the joint it may be necessary to remove them by open operation

The complication of traumatic myositis ossificans is particularly liable to occur after dislocations of the elbow in which there are associated fractures close to the joint

A lateral or medial dislocation of the elbow is reduced and treated on lines similar to those described for the backward variety

A forward dislocation of the radius at the elbow joint

relation of these bony points will differ from the normal, the olecranon being more prominent posteriorly In the case of a forward displacement of the radius combined with a fracture of the upper end of the ulna care must be taken not to overlook the radial displacement when the fracture of the ulna is observed. As in all injuries around the elbow joint examination must be made for any nerve injury

It is not uncommon to find a fracture of one of the adjacent bones associated with the ordinary backward dislocation of the elbow the coronoid process of the ulna being that most frequently injured. Fractures of the head of the radius and less commonly chips off the lower end of the humerus also occur

Treatment Manipulation for reduction of the dislocation must be carried out with the joint in flexion An anaesthetic is usually required A simple method of reduction *of a backward dislocation is to flex the elbow around* one's knee As this is done the knee acts as a fulcrum and separates the ulna from the lower end of the humerus so that as the forearm is pulled in its long axis which is the next movement the bones slip forwards and into position, the coronoid process clearing the lower end of the humerus Reduction is usually easy and the bones are felt to snap back into position. If there is a tendency for the bones to slide backwards out of position again it usually means that the coronoid process of the ulna has been separated. After reduction, provided there is no fracture the elbow should be rested in a sling at a little less than a right angle and with the arm bandaged to the trunk for about ten days after which gentle active movements are begun Earlier movements sometimes cause muscle spasm and a slower rate of recovery In the majority of cases where there has been no fracture there is a complete return of function this is very slow in some people particularly rheumatic subjects but it is usually complete in about six weeks

Where there is an associated fracture the manipulation for reduction is the same and the dislocation may remain reduced with the arm only in a sling or suspended from the neck by a collar and cuff But when displacement

readily recurs due to a fracture of the coronoid process it may be necessary to immobilise the elbow in a plaster of Paris cast which extends from the shoulder to the heads of the metacarpals When the coronoid process is fractured movements should not be commenced for four weeks but with a slight fracture of the head of the radius complete fixation for two to three weeks is usually sufficient In some fracture-dislocations of the elbow an X ray examination will

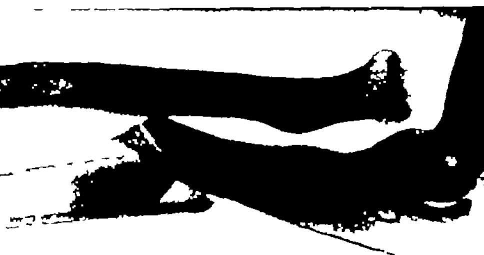


FIG 75 Dislocation of the radius (Monteggia fracture) The head of the radius is displaced forwards in relation to the humerus, the orbicular ligament surrounding it being torn The shaft of the ulna is fractured with angulation anteriorly In this classical lesion the displacement of the radius is sometimes overlooked with disastrous results to the movements of the joint.

show a number of chips of bone the origin of which cannot certainly be determined If these seem to be in the joint it may be necessary to remove them by open operation

The complication of traumatic myositis ossificans is particularly liable to occur after dislocations of the elbow in which there are associated fractures close to the joint

A lateral or medial dislocation of the elbow is reduced and treated on lines similar to those described for the backward variety

A forward dislocation of the radius at the elbow joint

relation of these bony points will differ from the normal the olecranon being more prominent posteriorly In the case of a forward displacement of the radius combined with a fracture of the upper end of the ulna care must be taken not to overlook the radial displacement when the fracture of the ulna is observed As in all injuries around the elbow joint examination must be made for any nerve injury

It is not uncommon to find a fracture of one of the adjacent bones associated with the ordinary backward dislocation of the elbow the coronoid process of the ulna being that most frequently injured Fractures of the head of the radius and less commonly chips off the lower end of the humerus also occur

Treatment Manipulation for reduction of the dislocation must be carried out with the joint in flexion An anaesthetic is usually required A simple method of reduction of a backward dislocation is to flex the elbow around one's knee As this is done the knee acts as a fulcrum and separates the ulna from the lower end of the humerus so that as the forearm is pulled in its long axis which is the next movement the bones slip forwards and into position, the coronoid process clearing the lower end of the humerus Reduction is usually easy and the bones are felt to snap back into position. If there is a tendency for the bones to slide backwards out of position again it usually means that the coronoid process of the ulna has been separated. After reduction, provided there is no fracture the elbow should be rested in a sling at a little less than a right angle and with the arm bandaged to the trunk for about ten days after which gentle active movements are begun Earlier movements sometimes cause muscle spasm and a slower rate of recovery In the majority of cases where there has been no fracture there is a complete return of function this is very slow in some people particularly rheumatic subjects but it is usually complete in about six weeks

Where there is an associated fracture the manipulation for reduction is the same and the dislocation may remain reduced with the arm only in a sling or suspended from the neck by a collar and cuff But when displacement

## Chapter XIII

# FRACTURES OF THE RADIUS AND ULNA

**(1) Fractures of the Radius**

(*a*) Fractures of the Upper End
(*b*) Fractures of the Shaft

**(2) Fractures of the Ulna**

(*a*) Fractures of the Olecranon Process
(*b*) Fractures of the Coronoid Process
(*c*) Fractures of the Shaft

**(3) Fractures of the Shaft of the Radius and Ulna**

**(4) Fractures of the Lower End of the Radius**

(*a*) Colles's Fracture
(*b*) Separation of the Distal Epiphysis
(*c*) Fracture of the Radial Styloid Process
(*d*) Smith's Fracture

## (1) Fractures of the Radius

(*a*) Upper End of the Radius While fractures of the head of the radius frequently occur those of the neck are uncommon Each will be discussed separately

*Fractures of the Head of the Radius* A fracture of the head of the radius without displacement is a common injury which may easily be overlooked It may result either from a fall on the outstretched hand or on the elbow With a fall on the hand the head of the radius strikes against the capitellum of the humerus and either a single fragment is broken off or a stellate fracture is produced The patient has pain in the elbow joint There is tenderness over the head of the bone which is easily felt on the postero lateral aspect just below the external epicondyle of the humerus X rays which must be good enough to show some detail in the bone will reveal the nature of the fracture The commonest type is a vertical crack through the head of

sometimes occurs when there has been a fracture of the shaft of the ulna without fracture of the radius This combined lesion is often known as a Monteggia fracture and will be further described with fractures of the ulna (p 129) but the importance of looking for the dislocation or subluxation of the radius whenever a fracture of the ulna alone is met with cannot be repeated too often

even two weeks Work may be resumed in five to six weeks from the time of the accident though occasionally pain and muscle spasm continue much longer for no apparent reason

If an X ray shows displacement of a single fragment, or if the head is mushroomed from a violent impact, the best treatment is to operate and remove the whole head of the radius Better functional results are obtained in this way than by conservative treatment not only because the head of the radius has been severely damaged but also because there is a severe contusion of the articular cartilage of the capitellum This damage to the capitellum does not show in an X ray but it is very apparent when the joint is examined at operation

If the deformed head of the radius is left to articulate against the contused cartilage of the capitellum a traumatic arthritis will rapidly develop and may progress to osteoarthritis in a few months or years

*Fractures of the Neck of the Radius* In a fracture through the neck of the radius the head is separated but if it is in a good position the elbow is immobilised for four weeks at a right angle in a plaster cast which extends from the anterior axillary fold to the heads of the metacarpals Active use of the fingers is encouraged while this is worn If the head is displaced it should be removed

(*b*) SHAFT OF THE RADIUS Fractures of the shaft of the radius generally occur as the result of a direct blow on the bone There is not usually great displacement when the ulna remains intact because the latter acts as a splint and prevents any great shortening or overlapping of the fragments

Displacement is influenced by the pull of the muscles which control supination and pronation When the fracture is above the insertion of the pronator radii teres the latter tends to draw the distal fragment towards the middle line while the proximal fragment is supinated by the short supinator muscle as well as by the biceps The latter also sometimes holds the proximal fragment in a position of flexion When the fracture is distal to the pronator radii teres both fragments may be drawn towards the ulna In

the bone, so placed that the smaller fragment is on the outer side of the head There is not usually any displacement and the condition may be overlooked, but it can be seen in the antero posterior X ray view as a line of fracture (Fig 26), often in the lateral view it can only be seen as an interruption or sharp angle in the cortical bone on the under surface of the head anteriorly



*Fig 26* *Fracture of the head of the radius* This is much the commonest type of fracture of the head of the radius, a vertical crack nearer the outer than the inner side being present without appreciable displacement The small fragment is held in position within the orbicular ligament.

Sometimes there are several fissures through the bone without displacement In other cases there is the typical single vertical fracture but the small fragment is displaced If this is the case crepitus may be felt on attempting rotation, or the latter may be extremely limited

Treatment When there is no displacement, reduction and rigid splinting are unnecessary The elbow should be immobilised in a collar and cuff sling which is kept on for about three weeks though the necessary time is variable Some patients can so easily and painlessly move the elbow in two weeks that the collar and cuff may be removed while others at the end of three weeks still have much muscle spasm on attempting movements in these cases it is wisest to keep the elbow immobilised for another one or

Fractures of the shaft of the radius alone in which displacement has occurred are often exceedingly difficult to reduce and what is perhaps more noteworthy once they have been reduced are very liable to become redisplaced *If attempts at reduction have failed or if the displacement* tends to recur then an open reduction is necessary Accurate anatomical position is obtained by operation and the fracture is immobilised by a plate or bone graft The treatment after an open reduction does not differ from that following a closed reduction except so far as the immediate treatment of the skin wound is concerned

## (2) Fractures of the Ulna

(*a*) Fractures of the Olecranon Process A fracture *of the olecranon usually follows a fall on the elbow though* it may occur from indirect violence by the pull of the triceps



Fig 28 Fracture of the olecranon process. Fracture into the middle of the greater sigmoid notch with moderate separation of the fragments. The small proximal fragment is held upwards by the triceps muscle.

In the majority of cases there is some and often considerable separation of the fragments though in others there is no displacement in the latter the aponeurosis over the

children a green-stick fracture in the distal part of the shaft of the radius with little or no displacement is very common (Fig 27)

**Treatment** When there is no displacement of the fragments the limb should be immobilised in a plaster of Paris cast which extends from the anterior axillary fold to the heads of the metacarpals the elbow being at a right angle the forearm midway between pronation and supination and the wrist straight This should be kept on until union has occurred no *sling is allowed* and the patient is encouraged to use the hand as much as possible



FIG 27 Green-stick fracture of the lower end of the radius. This is a classical position for this type of fracture. The bulge seen on either side of the bone though it may be slight, is absolutely characteristic of a green-stick fracture

When there is *displacement* an attempt should be made to correct it by traction The elbow is first flexed and then if *the fracture is above the* insertion of the pronator radii teres the forearm is supinated and powerful traction is made while at the same time the fractured ends are manipulated into position as far as can be done through the overlying muscles The method of reduction when the fracture is below the insertion of the pronator radii teres is similar except that the forearm should not be supinated.

Correction of overlapping and the drawing of the distal fragment over towards the ulna is sometimes overcome by adducting the hand to the ulnar side as traction is made If good or fair correction of the displacement is obtained the limb is immobilised in a plaster cast as described above for fractures without displacement and the after treatment is the same

For a green-stick fracture at the lower end of the radius a dorsal plaster slab for two to three weeks gives sufficient immobilisation

ment the elbow should be immobilised in a collar-and-cuff sling for two to three weeks when gentle active movements are commenced In cases where there is separation of the coronoid in association with a dislocation the latter should be reduced and the elbow immobilised in a plaster cast at a little less than a right angle for three weeks It is essential to see with skiagrams that the reduction of the dislocation and the position of the coronoid are satisfactory after putting on the plaster Gentle movements are allowed at the end of the three weeks, and though recovery is often slow an almost complete range of movement should be obtained

(c) FRACTURES OF THE SHAFT OF THE ULNA When there is no fracture of the radius fractures of the shaft of the ulna alone are usually the result of a direct injury As a rule there is little displacement and immobilisation of the arm in a plaster cast reaching from the axilla to the knuckles with the elbow at a right angle the forearm midway between pronation and supination and the wrist straight is the best treatment The cast should be kept on for six weeks during which the hand should be used as much as possible

A typical though not very common combined injury is that shown in Fig 26 in which there is a fracture of the ulna at the junction of the upper and middle thirds in association with a forward dislocation of the radius at the elbow joint Unless the skiagram is scrutinised carefully the displacement of the radius may easily be overlooked the fracture of the ulna being so obvious There is usually a forward displacement of the proximal ulnar fragment, though sometimes only angulation convex anteriorly By making traction on the forearm with the elbow flexed and at the same time pressing the displaced head of the radius back into position a reduction of the fracture and dislocation can be effected. The elbow should then be immobilised in a plaster cast at a little less than a right angle great care being taken not to imperil the venous or arterial circulation It should be kept so for six weeks and then gentle active movements commenced. Ligaments may interfere with the reduction of the head of the radius in

olecranon is probably not torn. The fracture is most often a single transverse one though it may be comminuted

The diagnosis is suggested by the history and tenderness over the olecranon and is confirmed if a gap between the fragments can be felt but this may be masked by swelling Care must be taken not to mistake the hard fibrinous bodies in an olecranon bursa for a comminuted fracture of the olecranon process the similarity in physical signs is sometimes quite striking an X ray examination will settle the question

**Treatment** If there is no separation of the fragments the arm should be immobilised in a plaster of Paris cast for three weeks with the elbow at a right angle The plaster should extend from the anterior axillary fold to the heads of the metacarpals with the forearm in mid pronation The patient uses the arm as much as possible while in this plaster

When there is separation open operation to reduce the fracture and fix the fragments should be carried out unless contra indicated for any reason—*e g* age of patient After operation the arm is immobilised in plaster for at least six weeks *Recently a different method of treatment has been* advocated This consists in complete excision of the proximal fragment of the fractured olecranon followed by firm suture of the aponeurosis Excellent results have been reported from this much easier method of dealing with the fracture but it is of course only practicable when less than half the olecranon is in the proximal fragment or when comminution is so extensive that any sort of repair of the bone is out of the question

*Prognosis* Provided good reduction of the fragments has been obtained a perfect functional result should follow

(*b*) FRACTURES OF THE CORONOID PROCESS Fractures of the coronoid process of the ulna are not common and occur either as one or more small cracks through the bone without displacement and perhaps associated with a fracture of the head of the radius or as a fracture through the base of the process with displacement and combined with a dislocation of the elbow joint in which the radius and ulna are *displaced* backwards In the former type where there is no displace-

to prevent the fragments of the radius lying in correct alignment In some cases it will be found that a better



FIG *9 Fractures of the shafts of the radius and ulna. The distal end of the proximal fragment of the ulna projected out through the skin and was covered with mud. On the right is seen the position after first-aid treatment on the left after reduction and immobilisation in plaster A perfect cosmetic and functional result was obtained.

alignment can be maintained with the forearm in some other position than that described above

In those cases where there is no displacement immediate fixation in plaster should be carried out

which case an open operation to replace the head may be required but the most usual cause of difficulty in reduction of the dislocation is failure to restore the length and alignment of the ulna

A fracture of the styloid process of the ulna often occurs It is of no great importance and is usually associated with a Colles s fracture If alone it may be treated as a severe sprained wrist—i e with immobilisation in plaster for a fortnight followed by active use with the wrist securely strapped for a further two weeks

## (3) Fractures of the Shaft of the Radius and Ulna

Fractures of the shaft of the radius and ulna usually result from direct violence though occasionally they are caused by an indirect injury as in the case illustrated in Fig 29 In the former group must be mentioned the trans verse fractures of the radius and ulna in their lower third caused by a back fire accident the starting handle flying round and striking the back of the lower third of the forearm. In children a green-stick fracture of these bones frequently occurs either with a negligible displacement or with angula tion convex forwards In adults there may be separation of the ends of the bones with overlapping and this fracture is amongst the most difficult in the body to reduce satis factorily by closed manipulation. In those cases where there is deformity the diagnosis is obvious and in those in which there is no deformity the history of the accident and localised tenderness will always demand an X ray examination.

**Treatment** In all cases of fracture of the shaft of the radius and ulna the elbow and the wrist should be im mobilised. The best form of splint is a plaster of Paris cast which should reach from the anterior axillary fold to the heads of the metacarpals the elbow being at a right angle and the wrist straight In most cases it is best to have the forearm in mid pronation or half way between this and full supination In the position of full supination which is sometimes advised the pronators are stretched and tend

guide the length of time required for immobilisation and well formed periosteal callus should be visible before the patient is allowed to use the arm unsupported, in an adult this is rarely in less than eight or ten weeks During the period of immobilisation the patient is encouraged to use the fingers hand and shoulder as much as possible Some stiffness of the elbow and wrist may be expected in elderly people For those cases in which there is displacement of fragments with overlapping three methods of treatment may be considered

(1) Reduction by manipulation and fixation in plaster
(2) Continuous traction
(3) Reduction by open operation

(1) For *reduction by manipulation* at least one assistant is necessary general or local anaesthesia may be employed If the latter is used the fractures in both the radius and the ulna must of course be injected with the novocain solution With the elbow at a right angle powerful traction is made in the long axis of the forearm this is best done by an assistant grasping the patient s thumb in one hand and the next three fingers in the other To prevent his grip slipping the fingers may be covered with a damp cloth Counter traction is made either by a second assistant grasping the lower part of the arm immediately above the flexed elbow or preferably by a broad bandage or a webbing strap which is passed around the arm just above the elbow and at the other end fixed to some immovable object (Fig 31)

This powerful traction should be maintained for about five minutes then the surgeon by manipulation at the site of fracture corrects any displacements which may be present The limb is then immobilised in *plaster of Paris* a long dorsal slab is put down the back of the arm forearm and hand as far as the heads of the metacarpals a short plaster slab is put down the front of the forearm and these are held in position by plaster bandages which should be sufficient in number to make a firm cast extending from the anterior axillary fold to the hand As the forearm is surrounded by



Fig 30 Fracture of the shafts of the radius and ulna in a child This is a common fracture and can usually be satisfactorily reduced by traction and manipulation before being immobilised in plaster of Paris

In children where there is angulation with a green stick fracture, the deformity should be corrected When angulation has to be corrected there is less likelihood of completely fracturing the bones or of over correcting the displacement if the forearm is laid on a flat surface with the convexity of the angulation uppermost and the arm straightened by firm steady pressure downwards on the angle than if the forearm is bent across a wedge or over the side of a table Owing to the frequency with which many children fall and refracture both bones of the forearm a rather prolonged period of immobilisation is advisable The plaster should be kept on for seven or eight weeks depending on the type of fracture age of the child and amount of callus seen. Even after this warning must be given against using the arm roughly

With adults the problem of treatment is more difficult When there is no displacement an unpadded plaster cast as described above should be put on immediately X rays should

and so holding the radius and ulna apart is a helpful one in overcoming this difficulty, but care should be taken when using it to avoid too great pressure as otherwise serious damage may be done to the skin and underlying tissues During the application of the plaster the assistant must continue his traction on the forearm only releasing it when the plaster has become hard

It is rare that transverse fractures of the radius and ulna are firm before ten weeks, and often a longer period of immobilisation is required During all this time the fingers hand and shoulder must be used as much as possible It is most important that during the first four weeks of immobilisation, skiagrams of the forearm should be taken weekly as these fractures are likely to slip out of position without the patient realising it If this happens and is not detected mal union will be found to have occurred when the plaster is removed, if the X ray films show it to be present the plaster must be removed at once and the deformity corrected and a new plaster cast put on

A satisfactory though not a perfect reduction can nearly always be obtained. If this is not obtained by manipulation the alternatives are—to institute continuous traction or to reduce by open operation If manipulation fails continuous traction is not likely to be successful so reduction by open operation is preferable

(2) *Continuous Traction* This is rarely used for fractures of the radius and ulna but it may be called for when a satisfactory position cannot be obtained by manipulation and plaster, and when for any reason operation is contra indicated or when suitable surroundings in which to perform it are not available

Although skeletal traction may be used by means of a Kirschner wire passed through the lower end of the radius and ulna or through the metacarpals skin traction is sufficient as a powerful pull is not required Skin traction is obtained for a fracture in the upper third of the radius and ulna by strips of extension elastoplast on the anterior and posterior surfaces of the forearm and wrist and these strips are attached to a cord by a wooden spreader placed a little

plaster there is a tendency for the fragments of the radius and ulna to be pressed together in the middle line so that



FIG 31 Traction and counter traction in reduction of fractures of both bones of the forearm.

cross-union is likely to occur to avoid this following the method of Böhler two wooden rods each about two and a half inches long are pressed into the plaster while it is still




FIG 32 Cross sections of forearm. A. shows fragments of fractured radius and ulna pressed together so that cross union is likely to occur B shows the bones held apart by short rods of wood pressed into the plaster anteriorly and posteriorly (*Böhler Treatment of Fractures*).

wet anteriorly and posteriorly so that they keep the radius and ulna apart These rods lie between the slabs of plaster on the front and back of the arm and the encircling turns of plaster bandages This manœuvre which acts by pressing the soft tissues on the front and back of the forearm together

of the ulna which is the straighter of the two bones is properly reduced the radius will be seen to be in a satisfactory position In the majority of cases, however it is necessary to expose both bones It may be found that the ends of the radius and ulna will remain in good position without any form of internal fixation but it is usually wiser to make certain that redisplacement does not occur by using a plate or bone graft After operation the limb should be immobilised in a plaster of Paris cast which must reach from the anterior axillary fold to the heads of the metacarpals and this should be maintained until a sufficiency of callus is seen by X rays

*Prognosis* Irrespective of treatment union of a fracture of the shafts of the radius and ulna is likely to be slow The rate of union will be accelerated if the patient uses the hand as much as possible while the arm is in plaster With children there seems to be a great tendency for the forearm to refracture unless immobilisation is rather prolonged and, for a fracture in the middle of the forearm six weeks should be the shortest time for fixation in plaster and eight weeks is often advisable In the case of adults the amount of callus at the end of eight weeks is sometimes very little and the X ray films must act as a guide as to the length of the immobilisation period It may be as long as ten or twelve weeks Non union provided immobilisation has been adequately carried out is unlikely to occur

In the case of the forearm a serious complication which does not occur elsewhere in the body may arise namely cross union If the radius and ulna become united to one another by callus the movements of pronation and supination of the forearm are lost This causes considerable disablement and should it arise an open operation will be necessary to separate the two bones unless the forearm is otherwise so badly injured as to make the operation not worth while Movements at the elbow and wrist should be of normal range after a fracture of the forearm though in bad cases there may be limitation in the movements of supination and pronation

distal to the fingers With a fracture in the distal part of the forearm traction can only be obtained on the skin by putting a fine cotton glove on the hand which has first been covered with Sinclair s glue or other suitable adhesive A powerful pull may then be exerted by means of tapes stitched to the tips of the glove fingers For continuous traction on a severe forearm fracture a Thomas s splint may be used

When a fracture of the forearm is being treated with continuous traction the elbow if in the extended position, is liable to become stiff For this reason the elbow is kept flexed to a right angle whenever possible A flexing piece is attached to a Thomas s arm splint and with the patient lying in bed with the shoulder abducted, the forearm points to the ceiling In addition to the traction on the forearm by weight and pulley it is necessary to secure the arm in the Thomas s splint by extension strips from the upper arm attached to the distal end of the splint When the arm is in this position early movement of the fingers is encouraged to prevent adhesions forming in the forearm and to promote a good blood supply to the site of the fractures After a few weeks when displacement of the fragments is no longer likely to occur the arm is taken down and a plaster cast from the anterior axillary fold to the heads of the meta carpals is put on the elbow being at a right angle The plaster is not removed until union has occurred but active use of the hand is made while the plaster is worn

(3) *Open Operation* This is not infrequently called for in cases of fracture of the radius and ulna because of the difficulty in obtaining and maintaining satisfactory reduction by closed methods An attempt to expose both bones through one incision should not be made It is better to employ a separate incision to expose each bone There is no hard and fast rule as to whether both bones should be exposed nor as to whether it is best to expose the radius or the ulna first Each case must be judged on its merits after a study of the X ray films It has been said that if the radius is put in correct alignment the ulna will look after itself but this is not always the case and sometimes if the fracture

monly seen in women over middle age It is due to indirect violence and the common accident is a fall in which the patient puts out her hand either forwards or backwards to save herself as she reaches the ground The appearance of the wrist when the characteristic displacements are present is so typical that diagnosis is easy, the shape of the wrist is classically likened to a dinner fork.

*Displacement* It is so important to understand fully the displacement of the distal fragment that it will be described in some detail Most Colles s fractures are impacted to a greater or less extent Fig 33 shows a moderately severe typical Colles s fracture In the lateral view displacements in two directions are clearly seen (*a*) backward displacement of the fragment (*b*) backward rotation or tilting of the fragment so that the distal concave articular surface of the radius faces somewhat backwards instead of directly forwards In the antero posterior view displacement in three directions is visible (c) The distal fragment is displaced proximally this is easily appreciated in a skiagram as well as clinically by noting the relative positions of the radial and ulnar styloid processes Fig 33 clearly shows that the radial styloid process has been displaced so that it is almost proximal to that of the ulna instead of being about one half of an inch distal to it This proximal displacement or shortening is mainly due to impaction (*d*) The distal fragment is displaced a little to the radial side this is not a very constant displacement (*e*) There is a rotation or tilting of the distal fragment to the radial side so that the distal concave articular surface (as seen in the antero-posterior view) is looking more towards the radial side than normal Finally the distal fragment and the whole hand may be rotated in the direction of supination Only one or two of these six displacements may be present in some Colles s fractures Displacement of the ulnar styloid process is not usually great and is unimportant A compound Colles s fracture is uncommon

Treatment The earlier the reduction of a Colles s fracture is carried out the easier it is to perform Local or general anæsthesia is required for reduction unless the dis

## (4) Fractures of the Lower End of the Radius

(*a*) COLLES'S FRACTURE In 1814 Abraham Colles of Dublin described in a manner which has not been improved



FIG 35 Colles's fracture. Before reduction showing typical displacements.

upon, the fracture at the lower end of the radius which has come to be known universally by his name

The fracture which is transverse is situated within an inch of the distal articular surface of the radius In the majority of cases either the internal lateral ligament of the wrist joint is torn or the styloid process of the ulna fractured While this fracture may occur at any age it is most com

has been reduced as described, the assistant maintains traction by grasping the thumb and second third and fourth fingers of the hand and pulling against the weight of the patient It is unusual for greater traction than this to be required but if it is, the method which has already been



FIG 35 Colles s fracture (same case as in Fig 33) in plaster after reduction

described for fractures of both bones of the forearm can be used

When a satisfactory reduction has been obtained the wrist is immobilised in a plaster splint with the wrist held straight i e in a position mid way between flexion and extension A complete plaster cast surrounding the wrist may be used but

placement is very slight or the patient is seen a few minutes after the accident In some cases there is little or no displacement and no reduction is required

Many ways of *reducing a Colles's fracture* have been described If one method is known and is found satisfactory in practice it is better to continue using it

In reduction there are certain definite movements to be carried out

First the fracture must be disimpacted This is done by forcible dorsiflexion of the distal fragment When disimpaction is complete the distal fragment is palmar flexed strongly pronated and drawn over towards the ulna

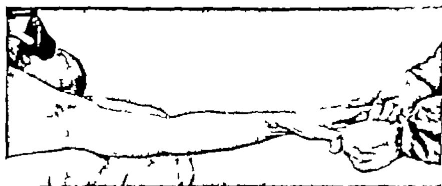


FIG 34. Traction on the limb *after* reduction of a Colles's fracture

Traction in the long axis of the limb is then necessary in order to maintain the reduced position While traction is kept up by an assistant three simple tests are applied to see whether the fracture is adequately reduced first the relative positions of the styloid processes of the radius and ulna are compared and then the dorsal surface and finally the anterior concave surface of the radius is felt if these appear normal and comparable with the sound side the reduction is likely to be satisfactory and plaster can be applied

It is very difficult to reduce and splint a Colles's fracture *successfully* without an assistant *although it* can be done It is best to have the patient lying down when the fracture

deviation and with the forearm pronated In this position the tendons which lie over the back of the radius at the lower end are stretched tight and hold the distal fragment forward in its correct position This is an excellent position for maintaining reduction of a Colles s fracture though not a good position from which to recover quickly the full movements of the wrist This position is therefore kept only for ten days after which the plaster is removed and the wrist gently put straight, and in this position a fresh plaster slab is put on and moulded well around the bony prominences of the wrist which is held firmly with the fracture reduced while the plaster sets In these cases it is best not to remove this second plaster until five weeks after the accident

In the after-care of a Colles s fracture it is wise to have another skiagram taken at the end of seven days to see that the fragments have remained reduced Sometimes the backward displacement recurs even with a well fitting plaster splint and if this is recognised at the end of seven days a second reduction can be carried out usually with complete success If it is not seen until the plaster is removed at the end of five weeks it is then much more difficult to obtain a good reduction

Many people are able to continue at work whilst in plaster Good function is usually obtained four weeks after the plaster has been removed in young and middle-aged subjects although older patients do not usually get good use of the hand and wrist for a longer period In those persons who have a tendency to rheumatism or who have a number of infected teeth or other septic foci pain may persist for a long time A place where pain sometimes persists is over the styloid process of the ulna but this pain seems to be met with much less frequently when the wrist is strictly immobilised for several weeks than when early massage and movements are commenced.

*Complications* Complications are few with a Colles s fracture Delayed and non union are almost unknown Injuries to nerves and main arteries are rare Occasionally one or more of the tendons on the dorsum of the wrist are injured The extensor longus pollicis is the one most

a dorsal slab is quite sufficient A slab (page 39) is quickly put on the back of the hand and forearm and moulded to the limb it reaches below to the heads of the metacarpals while above it should end just below the elbow allowing sufficient space for the joint to be fully flexed while still wet it is fixed in position by a wet gauze bandage which below comes through but must be kept well up into the cleft between the thumb and index finger so as to allow full movement of the latter at the metacarpo-phalangeal joint When the plaster has set a turn of one-inch adhesive strapping is put securely around the lower part of the splint and the palm of the hand it is put through the first cleft so as to hold the hand well up to the splint Great care must be taken to see that the fingers can be flexed fully into the palm. Finger movements are begun immediately A sling is not allowed after the first forty-eight hours The patient is encouraged to use the shoulder elbow and fingers as far as possible all the time the splint is worn, for by doing so the stiffness which is likely to arise when the arm is rested in a sling never occurs in any of these joints The splint is kept on for about five weeks in a young person and where there is no comminution three weeks is sufficient but with aged persons and comminuted fractures a longer time is necessary If when the splint is removed there is found to be much muscle spasm and pain on attempted movements the hand should be immobilised for a further period of a week or until they have disappeared. Pain and spasm disappear more quickly by thus immobilising the wrist again than by starting massage and movements

Contrary to what has sometimes been said a Colles's *fracture does not always readily remain in good position* after reduction, and this must be remembered when putting on the plaster The cases in which the displacement is particularly likely to recur are those in which the bone on the dorsal side of the distal end of the proximal fragment is comminuted or compressed *so that it gives little support* to the distal fragment after reduction and does not keep it in place In this type of case therefore it is best to put the plaster slab on with the wrist held in flexion and ulnar

deviation and with the forearm pronated In this position the tendons which lie over the back of the radius at the lower end are stretched tight and hold the distal fragment forward in its correct position This is an excellent position for maintaining reduction of a Colles s fracture though not a good position from which to recover quickly the full movements of the wrist This position is therefore kept only for ten days after which the plaster is removed and the wrist gently put straight and in this position a fresh plaster slab is put on and moulded well around the bony prominences of the wrist which is held firmly with the fracture reduced while the plaster sets In these cases it is best not to remove this second plaster until five weeks after the accident

In the after-care of a Colles s fracture it is wise to have another skiagram taken at the end of seven days to see that the fragments have remained reduced Sometimes the backward displacement recurs even with a well fitting plaster splint and if this is recognised at the end of seven days a second reduction can be carried out usually with complete success If it is not seen until the plaster is removed at the end of five weeks it is then much more difficult to obtain a good reduction

Many people are able to continue at work whilst in plaster Good function is usually obtained four weeks after the plaster has been removed in young and middle-aged subjects although older patients do not usually get good use of the hand and wrist for a longer period In those persons who have a tendency to rheumatism or who have a number of infected teeth or other septic foci, pain may persist for a long time A place where pain sometimes persists is over the styloid process of the ulna but this pain seems to be met with much less frequently when the wrist is strictly immobilised for several weeks than when early massage and movements are commenced

*Complications* Complications are few with a Colles s fracture Delayed and non-union are almost unknown Injuries to nerves and main arteries are rare Occasionally one or more of the tendons on the dorsum of the wrist are injured The extensor longus pollicis is the one most

frequently involved It may be torn at the time of the fracture or being frayed, may give way a few weeks later



Fig 36 Fig 37

Figs 36 and 37 Separated epiphysis of the lower end of radius. The epiphysis, in addition to being displaced backwards, is tilted backwards through an angle of nearly 90 degrees, so that the distal articular surface faces backwards. In Fig 38 good reduction has been obtained and the articular surface faces directly distally

when full use is recommenced The tendon should be repaired by operation

Mal union is not uncommon. It may be due to incom plete reduction or insecure splintage or too early removal

of the splint If it is seen within four to five weeks of the injury it is usually possible to refracture—over a wedge if necessary—and put the fragments into good position After five weeks an osteotomy will usually be necessary to obtain reduction. The radius is approached from the lateral side behind the brachioradialis *supinator longus* After division of the bone the fragments are manipulated into the best position possible and the wrist immobilised with plaster in the flexed position With mal union a very fair degree of function is often present, and except in young adults operation is best avoided unless after a fair trial the function is definitely poor

(*b*) SEPARATION OF THE DISTAL EPIPHYSIS OF THE RADIUS This is a common injury in children and occurs from the same type of injury as that which in the adult causes a Colles s fracture The distal epiphysis is displaced dorsally, and is usually also rotated backwards Diagnosis is easy when there is considerable deformity but it is only by X ray examination that an accurate diagnosis can be made in the less severe cases

Treatment Treatment is by immediate reduction A general anæsthetic is usually required The method of reduction is similar to that described for Colles s fracture Even though it be quite a small child it is surprising what strength is often required to reduce the displacement fully It is always advisable to have a skiagram after reduction to check the position, as it is not so easy to tell the position by palpation as it is with a Colles s fracture in an adult Complete reduction is important in order to avoid any interference with normal growth which occurs at the lower end of the radius When there is no angulation between the fragments growth will often smooth out any deformity during the course of a few years—but with angulation a deformity may easily persist

After reduction the wrist is immobilised with a dorsal plaster of Paris slab in a straight position as in the case of a Colles s fracture This is kept on for three weeks but a sling is not allowed For another week the hand should be used carefully, after which normal use may be resumed

In most cases of backward displacement of the distal radial epiphysis there is a small triangular fragment of the posterior part of the distal end of the diaphysis fractured and displaced backwards with the epiphysis, it is of no importance and usually assumes its normal position when the epiphysis is replaced

(c) Fracture of the Radial Styloid Process A fracture such as is shown in Fig 38 is not infrequently seen It is not really only the styloid process which is separated as the fracture reaches the lateral side of the radius a half to three-quarters of an inch from the tip of the styloid process The fracture involves the wrist joint This fracture is usually seen in adults and may result from a fall on the hand or from a back fire while cranking up a motor car It has been called a chauffeur s fracture A variety of fractures in the region of the wrist have been called chauffeur s fractures but all that is meant is that the fracture was caused by the back fire of a car Such an accident may occur in several ways either by a hyperextension injury of the wrist when the hand gripping the starting handle does not leave go quick enough or by the handle striking the back of the wrist as it swings violently round or by the person s arm being jerked off the handle against some part of the car As the injury may be a typical Colles s fracture or one of the radial styloid process or a transverse fracture of the lower part of the shaft of the radius and ulna or a fracture of the carpal



Fig 38 Fracture of the lower end of the radius involving the wrist joint This is one of the varieties of fracture which may result from a back firing accident.

scaphoid and as there are several types of accident which may cause the injury the term chauffeur's fracture" is best avoided, as it is misleading rather than useful

In the majority of fractures of the radial styloid process there is no displacement though occasionally there may be some lateral and upward displacement of the distal fragment The latter should be replaced by pressure over the outer side of the lower end of the bone while traction is made on the hand The wrist is immobilised mid way between flexion and extension in a position of slight ulnar deviation by a dorsal slab of plaster which reaches from the heads of the metacarpals to just below the bend of the elbow as for a Colles's fracture This is kept on for three weeks when there is no displacement but when there has been displacement it is not removed for four weeks During this time use of the hand is allowed and encouraged as much as possible no sling being permitted

Although the wrist joint is involved there is usually a rapid return of function with no permanent disability Full use may be allowed in five weeks and heavy work permitted in six

(*d*) Reversed Colles's Fracture (Smith's) This is sometimes called a Smith's fracture' The line of fracture is somewhat variable though usually approximately similar to that of a Colles's fracture the distal fragment however is displaced forwards There is often comminution and the line of fracture is sometimes oblique in an antero posterior direction and for these two reasons it is sometimes quite difficult to maintain the proper position of the fragments after reduction

Under local or general anæsthesia the wrist is flexed if impaction is present in order to separate the fragments Traction is made on the wrist which is then extended The wrist is immobilised at a position of 20° of extension in a plaster cast which extends from the heads of the metacarpals to just below the elbow but allows full use of the fingers and thumb In a straightforward case five weeks immobilisation is sufficient but in cases where the fracture is comminuted and tends to slip out of correct alignment it is

In most cases of backward displacement of the distal radial epiphysis there is a small triangular fragment of the posterior part of the distal end of the diaphysis fractured and displaced backwards with the epiphysis It is of no importance, and usually assumes its normal position when the epiphysis is replaced

(c) Fracture of the Radial Styloid Process A *fracture such as is shown in Fig 38 is not infrequently seen* It is not really only the styloid process which is separated, as the fracture reaches the lateral side of the radius a half to three-quarters of an inch from the tip of the styloid process The fracture involves the *wrist joint* This *fracture* is usually seen in adults, and may result from a fall on the hand or from a back fire while cranking up a motor car It has been called a 'chauffeur's fracture A variety of fractures in the region of the wrist have been called chauffeur's fractures but all that is meant is that the fracture was caused by the back fire of a car Such an accident may occur in several ways either *by a hyperextension injury* of the wrist when the hand gripping the starting handle does not leave go quick enough or by the handle striking the back of the wrist as it swings violently round or by the person's arm being jerked off the handle against some part of the car As the injury may be a typical Colles's fracture or one of the radial styloid process or a transverse fracture of the lower part of the shaft of the radius and ulna or a fracture of the carpal



Fig 38 Fracture of the lower end of the radius involving the wrist joint This is one of the varieties of fracture which may result from a back firing accident

## CHAPTER XIV

# FRACTURES AND DISLOCATIONS OF THE CARPUS

## Fractures of the Scaphoid

THE scaphoid is fractured far more commonly than any of the other carpal bones With early and efficient treatment the fracture will unite and a perfect functional result will be obtained in the great majority of cases On the other hand



FIG 39 Fracture through the waist of the scaphoid.

advisable to keep the wrist immobilised for seven or eight weeks During this time a sling is not allowed, and full use of the hand elbow and shoulder is encouraged. In a number of cases of Smith s fracture difficulty is experienced in *maintaining good reduction of the fragments* this is often found to be more troublesome than in Colles s fractures If however in these cases the best alignment possible is obtained the wrist put up in extension with some ulnar deviation, and active use of the fingers commenced from the first a very good functional result will be obtained—usually as good if not better than when an open operation is performed The latter is very rarely indicated

adequate blood supply, with the result that union readily occurs

**Diagnosis** The patient experiences severe pain in the wrist There is tenderness on pressure over the scaphoid particularly in the anatomical snuff box, and sometimes anteriorly over the tuberosity of the bone Full abduction of the thumb causes pain and this and other tests have *been described as characteristic points in the diagnosis* In many cases however it is quite impossible to diagnose a fracture of the scaphoid from a sprained wrist with certainty To avoid mistakes X rays should be taken in every case of sprained wrist The X rays must be good ones and must include an oblique view as well as the usual antero pos terior and lateral. Quite often a fracture which was invisible when the wet X ray films were examined is detected when the films are dry especially if the scaphoid shadow is inspected with a hand lens. Fine hair line cracks can be picked out which were invisible at ordinary scrutiny



FIG 41 Oblique view of wrist showing *fracture of tuberosity of scaphoid.* Bony union takes place readily

If a fracture cannot be seen after careful examination of the films but clinical evidence suggests that the scaphoid is injured it is better to regard the case as one of fracture and immobilise the wrist in plaster for two or three weeks At the end of this time some bone absorption will have taken place so that what was at first an invisible crack has widened out and now can be seen if a fresh X ray is taken.

In the past non union of fracture of the scaphoid was the rule because the diagnosis was so often missed and the patient treated as a case of sprained wrist '

delay in diagnosis or ineffective treatment will usually lead to severe and maybe permanent disablement This is because if it is not properly treated a fracture of the scaphoid fails to unite by bone and arthritis of the wrist develops

The scaphoid is most commonly fractured as the result of a hyper-extension injury to the wrist such as a fall on the outstretched hand or a back fire while cranking a petrol engine There are three varieties of fracture —



Fig 40 Fracture near proximal end of scaphoid—polar fracture Bony union occurs slowly

(1) Fracture through the waist of the scaphoid

(2) Fracture through the proximal part of the bone which separates the proximal pole—a ' polar fracture

(3) Fracture of the Tuberosity

The first is the commonest variety Less commonly the bone is fractured in its proximal part so that the fragments are of unequal size the smaller, that next to the lunate has a poor blood supply and bony union is slower in occurring than with the waist fracture An excellent example of the effect of a deficient blood supply on bone is found in this type of fracture for in skiagrams taken a few months after the injury the small proximal pole may appear much denser than the larger distal one This avascular necrosis ' of the proximal pole takes place in about one third of the fractures of this type Once avascular necrosis is established union will never occur and special treatment is required

The less common fracture of the tuberosity of the scaphoid has a better prognosis as this part of the bone is extra-articular has ligaments attached to it, and has an

Union will occur in a surprising number of these 'neglected' fractures once proper treatment has been instituted

If there is radiological evidence of non union simple immobilisation in plaster will not cure the condition An operation for drilling or grafting the bone is indicated



Fig 42. Same case as in Fig. 39 showing bony union

the operation must be followed by prolonged immobilisation of the wrist

In polar fractures when avascular necrosis of the proximal fragment is present there is nothing to be gained by putting the wrist in plaster Union will not take place and unless something is done the proximal pole of the

**Treatment** Cases must be considered in three groups First recent or fresh fractures Secondly cases which have been missed or neglected for several weeks or months and third the ununited, old fracture

(1) *Recent Fractures* As soon as a fracture of the scaphoid has been diagnosed the wrist should be immobilised in a plaster cast The cast extends from the necks of the five metacarpals to about three-quarters of the way up the forearm The wrist should be in a position of slight dorsi flexion and slight pronation. The cast must fit well and is unpadded except for a small piece of felt over the head of the ulna

However skilfully it has been applied the cast may become loose broken or uncomfortable at any time The whole success of treatment depends on maintaining the integrity of the cast until union has occurred, the patient must therefore be seen at frequent and regular intervals. At these inspections a new cast must be applied without hesitation if the old one has become ineffective in immobilising the wrist Three weeks is the longest period which should be allowed to elapse between each inspection At the end of two months it is safe to remove the plaster and X ray the wrist to see whether union has occurred. If the films show undoubted union by bone the plaster is discarded but if there is the least doubt a fresh cast is applied and another period of six or eight weeks immobilisation is advised

Because of the careful and if necessary prolonged application of this method of treatment we can now claim that most of these fractures will unite by bone and with perfect functional results

(2) *Missed or Neglected Cases* Very often a fracture of the scaphoid is diagnosed for the first time many weeks after the injury which caused it Provided an X ray shows no sclerosis of the fracture line denoting established non union and that the proximal pole of the scaphoid does not appear dense and avascular treatment is the same as for a fresh fracture A plaster cast is applied and the wrist is continuously and effectively immobilised until union has occurred.

injury, and subluxation or dislocation of one or more bones may also be present

Any of these fractures are best treated by immobilisation in plaster for three to four weeks If there is then great muscle spasm longer fixation is advisable Occasionally operative treatment to remove one or more or even the whole proximal row of carpal bones may be indicated but the *results are not good*

## Dislocations of the Wrist and Carpus

A dislocation of the wrist joint proper *i e*, the joint between the radius and ulna proximally and the carpus distally is surprisingly rare Displacements do occur at this joint but they are always irregular and associated with some fracture An attempt must be made to correct all displacements the wrist is then immobilised in plaster for six weeks During this time it is important that the elbow and fingers should be used as much as possible

DISLOCATION OF THE SEMILUNAR. This is the commonest dislocation at the wrist It usually results from a hyperextension injury with the result that the anterior part of the carpus is opened up and the semilunar is displaced forwards A backward dislocation very rarely occurs It is not uncommon to find that there is an associated fracture of the scaphoid and in this case the fragment of scaphoid adjacent to the semilunar may also be displaced forwards Clinically the patient has great pain and swelling of the wrist with limitation of movement A characteristic sign, which may suggest the diagnosis is that of pain or tingling in the distribution of the median nerve this is due to direct pressure on the nerve by the forwardly displaced semilunar crowding the carpal tunnel Another characteristic sign but one which is not always present is that of alteration in the relative positions of the heads of the second third and fourth metacarpals Normally the knuckle of the middle finger is more prominent than the others but with a dislocation of the semilunar this knuckle may lie on the same level as those of the index and ring fingers The

scaphoid will become flattened and deformed and arthritis of the radio-carpal joint will supervene In these cases the avascular pole of the scaphoid should be excised. This operation produces satisfactory functional results although there is still a risk that osteo-arthritis of the wrist will develop in the future

(3) *Ununited Old Fractures* In spite of what has been said about the disabling effects of non union in these fractures it is none the less perfectly true that many individuals retain full and painless use of the wrist for many years in spite of an ununited fracture of the scaphoid It is often not until osteo-arthritis develops that painful and disabling symptoms arise Sometimes following a fresh injury to the wrist an X ray shows what must be an old ununited fracture of the scaphoid. The symptoms which arise either spontaneously or after injury can often be completely relieved by four to six weeks rest in a plaster cast If so all well and good and no further treatment is necessary However pain and disability may persist and may gradually increase in severity In that case it may be advisable to perform an arthrodesis of the wrist or to provide a permanent moulded leather support

## Fractures of other Carpal Bones

Fractures of the carpal bones other than the scaphoid are uncommon The semilunar and cuneiforms are those most frequently fractured and a characteristic and not rare fracture is one in which a very small fragment of the posterior part of the bone is separated It cannot be seen in an antero posterior skiagram but shows clearly in a lateral view lying behind the carpus If not immobilised in slight dorsiflexion there is difficulty in regaining this movement It is advisable to keep the wrist fixed in a plaster cast for about three weeks

Fractures of other carpal bones are very variable Any bone may be fractured alone and in severe wrist injuries it is not uncommon to find several bones fractured. Indeed it is often difficult to determine the exact extent of the bony

carpal tunnel opened, and the tendons and median nerve are retracted In cases treated within seven days of injury, and when the bone is not fractured an attempt should be made to replace it in its normal position If this is successful the after treatment is as before Should this fail or if the bone is fractured it should be removed A wrist with a very fair function is obtained after removal of the semilunar

Following a closed reduction, an uncomplicated case of dislocated semilunar should have a function indistinguishable from normal

diagnosis is confirmed by X rays Though the dislocation can be recognised in the anterior view it is shown more clearly in the lateral view In the severe degrees the articular surfaces of the semilunar are completely separated from the radius and os magnum, in the less severe cases the articular surfaces of the semilunar and radius may still be in contact to some extent

Treatment Early reduction of the dislocation is essential It used to be said that reduction could only be performed by open operation but this is not the case If the patient is seen within four or five days of the injury reduction by manipulation can be accomplished in nearly every case An X ray film of the dislocated semilunar clearly shows that the space which it should occupy i e the space between the os magnum and the radius is considerably diminished. From this it is realised that the essential step in the reduction of a dislocated semilunar is to open up this narrowed gap by making powerful traction on the hand in the long axis of the limb

With the patient recumbent and the elbow at a right angle counter traction is made on the upper arm by a firm strap attached to some rigid object An assistant makes powerful traction on the hand by grasping the fingers with a damp cloth so that they will not slip After a few minutes it should be possible to reduce the semilunar by pressing it back into position with the thumb placed over the front of the wrist The reduction is sometimes aided by first hyper extending the wrist and then, with the thumb over the semilunar anteriorly flexing the wrist Reduction should *always be confirmed by X rays The wrist is then im*mobilised in a plaster cast as for a Colles s fracture for about a fortnight Plaster is then removed the wrist strapped with elastoplast and ordinary use allowed If there is an associated fracture of the scaphoid immobilisation will, of course have to be much longer

In those cases where reduction has not been obtained by manipulation an open operation should be performed, as an unreduced dislocation of the semilunar leaves a very bad wrist The bone is exposed by an anterior incision the

some stiffness may occur but even where there is no displacement these fractures are most satisfactorily treated in plaster The cast is made with a dorsal slab secured to the forearm and hand by one or two plaster bandages the plaster is well moulded into the palm of the hand The finger corresponding to the injured metacarpal is then flexed at the metacarpo phalangeal joint by a strip of adhesive strapping one inch wide secured to the plaster by another broad band of strapping round the wrist When the fourth or fifth metacarpal is fractured it will be found more comfortable to strap both the fourth and fifth fingers together

After about ten days the fingers can be released and active movement encouraged but the supporting cast must usually be retained for at least three weeks It is most important to fix the fingers in flexion and not in extension After the fingers have been kept in flexion for ten days it is found that they can be stretched out to full, or almost full extension within five or ten minutes of removing the bandage but if fingers are fixed in extension on some straight splint for that time it often takes particularly in old people several days or sometimes even weeks before full flexion is obtained for this reason the position of flexion is advised even in fractures without displacement

Where there is a fracture with displacement this must be reduced with the patient under an anæsthetic The most usual deformity is that of angulation with the convexity backwards This displacement can be easily overcome by manipulation and the reduced position is maintained by careful moulding of the plaster cast on the back and front of the hand, the affected finger is immobilised in flexion by strapping

If overlapping has occurred it is necessary to maintain a little continuous traction on the finger or fingers corresponding to the fractured bone or bones There are several splints which are used for maintaining traction on the fingers, the best is that described by Böhler It consists of a piece of wire bent into the shape shown in Fig 6 covered by cellulose or wool which is secured by a bandage The splint

## Chapter XV

# FRACTURES OF THE METACARPALS

Fractures of the metacarpal bone of the thumb being rather different from those of the other metacarpals will be described separately The metacarpals of the other four fingers are commonly fractured by direct or indirect violence The commonest fracture is one obliquely through the shaft without appreciable displacement A transverse fracture of the shaft is also common and is due to direct violence often several metacarpals are fractured side by side In these cases there may be displacement — either angulation or overlapping A fracture through the neck of a meta carpal often occurs and may show angulation, convexity backwards so that if the displacement is not corrected before union is firm there will be limitation of extension of the finger a fracture of the fifth metacarpal at this site is particu larly common A fracture through the base of one or more metacarpals is common but from the attachment of the many surrounding ligaments there is usually no displacement and often only slight symptoms so that the condition is overlooked by the patient



Fig 43 Oblique fracture of the fifth metacarpal without displacement

**Treatment** In many fractures of the metacarpals there is little displacement and the fragments are held together pretty well by the interosseous muscles Prolonged im mobilisation is unnecessary and inadvisable because trouble-

phalangeal and proximal inter phalangeal joints The finger being on the outer side of the curve of the splint will, as it is bent be drawn out in continuous traction and will thus maintain the metacarpal in a satisfactory position A greater or less degree of flexion will be needed in different cases If there is angulation at the fracture convexity posterior it may be held in the corrected position by moulding the plaster so that it makes pressure over the convexity of the fracture which is protected from the hard plaster by a piece of felt

## Fractures of the First Metacarpal

Although the fractures described as occurring in the other metacarpals may also be found in the first they are rare there are however, two fractures at the base of the bone which are common and characteristic These two must not be confused with each other as their treatment and prognosis differ They are

(1) Bennett s fracture (Fig 45B)
(2) Transverse fracture about half an inch from the base (Fig 45A)

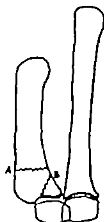


Fig 45 Fractures of the base of the first metacarpal. Both these fractures are common.

A. Transverse fracture at base not involving the joint; often impacted; easy to treat.

B Bennett s fracture. The distal fragment is displaced upwards so that it is really a fracture dislocation difficult to treat satisfactorily

BENNETT S FRACTURE. This fracture described by an Irish surgeon, Halloran Bennett in the middle of the last century commonly occurs as the result of a force which drives the shaft of the bone up against the trapezium and shears off a triangular fragment of bone on the inner side of the base (Fig 46) It is important to remember that this fracture is really a fracture-dislocation A small fragment remains attached to the adjacent bones i e the base of the second metacarpal and the trapezium but the main fragment becomes displaced outwards and somewhat proximally the ligaments being

is fixed to the patient's wrist and hand by a plaster cast which incorporates a dorsal slab There are two methods by which the finger may now be secured to the end of this splint The simpler is to apply strips of adhesive strapping to the front and back of the digit leaving long ends which are tied to the end of the splint Fixation can be made more secure by encircling finger and splint with two or three

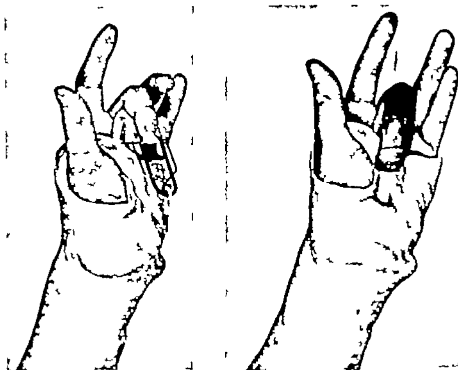



FIG 44. Two methods of attaching the finger to wire finger splint. (1) A *stainless steel pin is inserted through the pulp of the distal phalynx* (2) The finger is secured by means of strapping

bands of strapping (Fig 44) Another method which can be used is to transfix the pulp of the finger near the tip with a piece of sterilised wire or a Brook's clip and tie this to the end of the Böhler splint There is a risk of infecting the finger but the method is particularly convenient when the fracture of a metacarpal is complicated by laceration of the corresponding finger The finger having been thus secured to the splint the two together are flexed at the metacarpo-



Fig 47 (A). Bennett's fracture-dislocation. Method of traction. Note pulp-traction pin and pad of felt at base of first metacarpal.

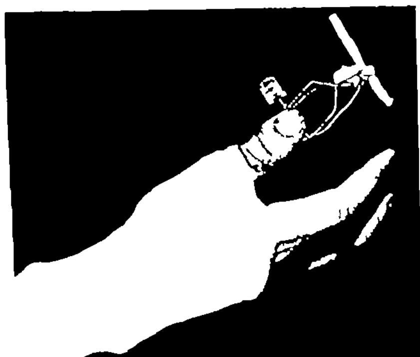


Fig 47 (B).—Bennett's fracture-dislocation. Plaster applied with traction on Böhler finger splint.

torn, this fracture commonly results from boxing often without gloves The clinical appearance is very characteristic there is pain and great tenderness associated with an unusual prominence of the base of the first metacarpal.

Treatment By pulling on the thumb in its long axis and pressing the base of the first metacarpal medially, reduction of a Bennett's fracture-dislocation is usually easy As soon as the pull and pressure are released however, the metacarpal immediately slips out of position causing the patient great pain. The difficulty in these cases is not so much that of reducing the fracture but of maintaining its position after reduction. Any method of splinting this type of fracture-dislocation should combine traction in the long axis of the thumb with pressure on the base of the first metacarpal bone A pull on the thumb can be achieved with a Böhler finger splint used in the manner which has been described for fractures of the other metacarpals The thumb can be secured to the splint either by strapping or by a Brock's clip although in this particular injury the latter is more effective



FIG 46 Bennett's fracture. The small fragment at the base of the first metacarpal on the medial side remains attached to the adjacent bones by ligaments. The base of the metacarpal becomes displaced laterally and somewhat proximally so that the condition is one of fracture dislocation The base of the metacarpal is easily felt as a bony prominence under the skin.

With the patient anæsthetised, the fracture-dislocation is reduced by traction on the thumb A piece of felt is placed over the base of the thumb metacarpal and a plaster cast is applied which incorporates the Böhler finger splint While the cast is setting the pull on the thumb is maintained and the plaster is moulded firmly over the protected base of the

CHAPTER XVI

# FRACTURES AND DISLOCATIONS OF THE PHALANGES OF THE HAND

FRACTURES of the phalanges are of frequent occurrence and are commonly caused by a crushing injury In many cases there is little or no displacement though in some there may be angulation or lateral displacement of a transverse or oblique fracture while in others there may be deformity combined with comminution. Angulation is commoner than lateral displacement, and the deformity is almost always one of angulation convex anteriorly The prognosis is always more serious when the fracture encroaches upon the metacarpo-phalangeal or interphalangeal joints There is sometimes a tendency to neglect fractures of the phalanges as being unimportant but mal union and stiffness of the adjacent joints may lead to prolonged or even permanent disability in the case of manual workers and as much care and attention should be paid to fractures of these small bones as to fractures of the femur and tibia



FIG 48 Fracture of distal phalanx of finger As in this case the fracture is usually due to a crush, the displacement is not of such a degree as to require reduction.

**Treatment** It is always preferable when treating fractures of the phalanges to have the finger in the flexed position rather than straight If a finger is kept straight for some weeks on a splint it becomes extremely stiff and great difficulty is experienced in trying to flex it On the other hand, a finger immobilised in the flexed position can be straightened more easily Furthermore if because of

metacarpal. As soon as the plaster has set the thumb is secured to the end of the finger splint (See Fig 47 )

The fracture will take about five or six weeks to unite After removal of the plaster there is at first a good deal of stiffness but with adequate exercises movement soon increases Even if the fracture-dislocation is left unreduced and mal union occurs a very fair functional result may be obtained but the cosmetic result is poor abduction is limited and a painful osteo-arthritis of the carpo metacarpal joint of the thumb is likely to occur

TRANSVERSE FRACTURES OF THE BASE OF THE FIRST METACARPAL. This is sometimes erroneously called a Bennett s fracture but it is essentially different in that there is no dislocation the base of the bone not being involved. The fracture is usually situated about half an inch from the proximal end is often impacted, and frequently there is some angulation of the fragment convexity outwards

Treatment An attempt should be made under anæsthesia if necessary to correct any angulation, but if this *cannot easily be done and the deformity is not great* an excellent functional result will be obtained if the fracture is immobilised with the slight deformity still present The thumb can be adequately fixed by a spica made of five or six turns of one-inch strapping around it and the wrist After three weeks it may be removed and active movements begun and, even though there is some angulation of the fragments which might apparently limit abduction, the full range of movement is usually obtained and there is no interference with function

For fractures of the middle and proximal phalanges with displacement the deformity is reduced by manipulation. As mentioned above this deformity is almost invariably angulation convex anteriorly, and is easily reduced by holding the finger firmly and flexing it while pressure is made over the point of angulation anteriorly In all cases of fractures of phalanges it is most important to see that there is no rotation of one fragment on the other in the long axis When the finger is straight such a deformity is easily overlooked but in flexion this deformity is obvious because the finger will be seen to tuck under its follow This is another reason why phalanges should be treated in flexion Rotation is easily corrected by twisting the finger When the angulation and rotation are corrected, the finger is immobilised in a similar manner to that described above The times for immobilisation and use are a week longer than when there has been no displacement

For fractures of the phalanges with displacements which are not readily corrected where there is comminution, or where joints are extensively involved, a little traction may be necessary to maintain reduction As the splint is fixed on it is so arranged that it lies along the anterior surface of the fractured finger With the splint and finger straight the latter is secured to the end of the splint This may be done in one of the two ways which have been described on p 160 When the finger has been thus secured to the end of the splint by one of these methods the surgeon grasps the splint and finger together and flexes them to an angle determined by the nature of the facture The more it is flexed the greater traction is put on the fracture because the finger is lying on the convex side of the curve of the splint If this splint is adjusted carefully and the position of the fragments controlled by X ray examination, the most difficult fractures of the phalanges can be held in satisfactory position provided the degree and the position of the curve of the splint are suited to each case While the spint is being worn the patient should move the other fingers as well as the elbow and shoulder as much as possible and a sling should not be worn Most of these fractures

damage to the interphalangeal joint movement is not regained a partly flexed stiff finger is more useful than a straight one The degree of stiffness which occurs in either position is much greater in older people

For fractures of the distal phalanges splinting is simply and efficiently carried out by surrounding the distal half of the finger with four or five turns of ordinary adhesive strapping If there is any displacement of the phalanx this should be corrected as far as possible by manipulation before the strapping is applied Displacement is however uncommon. This strapping is removed after three weeks

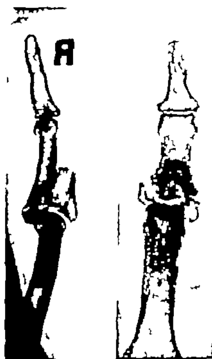



FIG 49 Comminuted fracture of middle phalanx involving the joint. Prognosis as regards movement is poor

For fractures of the middle and proximal phalanges with out displacement the finger should be immobilised in a semi flexed position on a Böhler finger splint which is placed along the palmar surface of the finger The splint should not be broader than the width of the finger it should not be padded, but only covered with adhesive strapping and should extend from the tip of the finger to the forearm. The splint is retained in position by a plaster cast extending from the knuckles to the upper third of the forearm when it has been applied the finger is secured to the splint by two or three turns of adhesive strapping This splint may be removed after three weeks and active movements and ordinary use of the hand carried out Heavy work should not be done for a further two or three weeks

are united after four weeks' immobilisation but some take longer and immobilisation must be continued

The results of fractures of the phalanges are very variable Simple fractures without displacement unite rapidly and a good range of movement returns, if a joint is involved there is often permanent stiffness Fractures of the proximal phalanges in which there has been the typical angular deformity are sometimes slow to unite and more often than not the flexor tendons become adherent to the fracture so that some limitation of movement occurs If the fracture is compound stiffness is more likely and if there is a compound fracture of the proximal phalanx with division of the flexor tendons and angular deformity of the bone, early amputation may well be the best course

Dislocations of the Fingers Dislocations may occur either at the metacarpo-phalangeal joints or at any of the interphalangeal joints They are common injuries and the distal bone is usually displaced backwards on the proximal the commonest injury being one of hyperextension at the joint It causes extreme pain and sometimes the patient himself, or a friend seeing the finger out of joint has pulled on it and reduced it completely

Treatment Except in the case of a dislocation of the metacarpo-phalangeal joint of the thumb reduction of a recent dislocation of a finger is not difficult Often without any anæsthetic reduction is obtained by quickly but powerfully pulling on the finger in its long axis and at the same time pushing the displaced phalanx forward If there is no immediate tendency for dislocation to recur the joint should be immobilised by binding it around with several turns of adhesive strapping These should not be put on too tightly at first because a considerable degree of swelling often follows a recent dislocation If the displacement tends to recur—and this is rare except when there is an associated fracture—the finger should be put up in flexion on a Böhler finger splint as described for fractures of phalanges A dislocation of the finger should be immobilised for two to three weeks with strapping but during this time the finger, provided it is not on a splint should be used as



FIG 50 Fracture of the middle phalanx with typical angular displacement.

FIG 51 The same fracture after correction of the deformity The finger is on a Bohler finger splint bent a little so that the convexity is at the level of the fracture.

MALLET FINGER This condition is strictly speaking, not a fracture, but is a tear of the extensor tendon of a finger or thumb at the point of its attachment to the base of the distal phalanx It is usually a subcutaneous injury without an external wound When X rays are taken a minute fragment of bone is sometimes seen torn off the base of the distal phalanx by the extensor tendon

*Treatment* *Whether a flake of bone is torn off by the* tendon or the tendon ruptured at its insertion the treatment is the same The finger should be splinted for six weeks *with the distal interphalangeal joint hyperextended as far as* it will easily go and with the proximal joint flexed to a right angle in order to relax the flexor profundus tendon This rather awkward position is best maintained by a small plaster cast The cast wears out quickly and careful supervision of the patient is necessary so that the plaster may be renewed before it becomes ineffective

In spite of careful treatment the result may be disappointing because the healed tendinous expansion stretches so easily and a slight residual flexion deformity is quite usual However a good functional result is to be expected in most cases

In order to avoid the somewhat disappointing result of conservative splinting it has been recently suggested that cases of mallet finger should be treated by operation and suture with fine stainless steel wire

much as possible actually some movement takes place at a joint which is strapped Swelling and pain often continue for a long time after a simple dislocation of the finger but until the swelling has completely subsided, which often takes months full flexion at the joint is not obtained. Radiant heat and massage are seldom of any help in getting rid of the swelling

The method of reducing a dislocation of the metacarpo-phalangeal joint of the thumb requires special mention. In a typical dislocation of this joint (Fig 52) where the phalanx is displaced backwards reduction, contrary to what might be expected cannot be obtained by a straight pull on



Fig 52

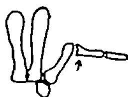


Fig 53.

Figs. 52 and 53 show a dislocation of the metacarpo-phalangeal joint of the thumb and the method of reduction by manipulation as described in the text.

the thumb The phalanx can, however easily be replaced if the thumb is grasped firmly and first hyperextended to about a right angle The base of the phalanx is then pushed distally (Fig 53) by the surgeon s thumb until it is articulating with the back of the head of the metacarpal if the joint is now slowly flexed, the thumb being held securely as this is done the dislocation will be found to be reduced. *In rare cases in which this manipulation fails* it may be necessary to perform an open operation The metacarpo-phalangeal joint is exposed on its palmar aspect and a portion of the anterior ligament will be found to have slipped in between the bones and to be preventing reduction. When this is pulled out with a sharp hook, reduction will be easy

When a dislocation of this joint has been reduced it should be strapped in a slight degree of flexion for two weeks *After this*, movements and use are allowed, but with the joint supported in strapping for a further two weeks

Fractures of the coccyx are rare, although it is very common for patients to complain of great pain in that region after a fall on it but in the majority of cases of coccydynia following trauma no fracture can be felt on palpation, nor can one be seen on X ray examination

**Treatment** In most fractures of the outlying parts of the pelvis there is no displacement which requires reduction Sometimes in the case of the anterior superior spine or the iliac crest it may be possible to replace the bone if it is displaced outwards or forwards With any fracture of the pelvis there is often some shock and considerable pain, and it is necessary for the patient to remain in bed for three or four weeks After this he may get up, but the pelvis is supported and made comfortable by a firm girth, bandage or elastoplast around it

## (2) Fractures through the Pelvic Ring

Fractures through the pelvic ring most commonly result from run-over accidents or from compression against a wall Another cause of the injury is a fall on to one foot from a height the thrust of the impact conveyed up the limb separates one half of the pelvis and displaces it upwards From the nature of the injury, patients sustaining a fracture of the pelvis are usually suffering from very severe shock and in many cases have other injuries either of bones or viscera The commonest complete fracture of the pelvis is the double vertical fracture of Malgaigne In this the anterior fracture runs through the superior and inferior rami of the pubic bone of one side while the posterior which is often on the opposite side passes through either the lateral piece of the sacrum or the iliac bone close to the sacro iliac joint, occasionally instead of a fracture the joint surfaces are separated. Sometimes there is a fracture through the pubic bones on both sides as well as a fracture posteriorly in such cases the medial parts of the two pubic bones may be displaced upwards together

A separation at the pubic symphysis does occur though it is much less common than a fracture

In those cases where a fracture of the pelvis results from

## Chapter XVII

# FRACTURES OF THE PELVIS

A large number of fractures of the pelvis have been described but it is convenient to discuss the subject under three headings

(1) Fractures through the outlying parts of the pelvis not breaking the pelvic ring
(2) Fractures through the pelvic ring
(3) Fractures of the acetabulum

## (1) Fractures through the Outlying Parts of the Pelvis, not Breaking the Pelvic Ring

The two ossa innominata together with the sacrum form the pelvic ring if the latter is broken at any point the term complete fracture of the pelvis is sometimes used. If the ring is not broken and the fracture is only through some part of the false pelvis the term incomplete fracture is used this is the type under discussion. The commonest fracture of this kind is through some part of the wing of the ilium The fracture may be comminuted, but there is not usually much displacement the muscles on either side of the bone keeping the fragments in position There is often a large hæmatoma associated with this fracture sometimes causing pressure on nerves particularly the external cutaneous nerve of the thigh

The anterior superior spine may be separated, but even if it is considerably displaced and unites in this position little disability follows Separation of the anterior superior spine has occurred in young people as the result of muscular pull.

The ischial tuberosity may be fractured by direct violence but the displacement is not usually of importance Fractures through the lower part of the sacrum occasionally occur but it is seldom that the bone is displaced forwards to any important extent The lower sacral nerves may be injured

the splints a ten pound weight is then attached to each splint, which must be suspended from pulleys and weights so as to hold the limbs off the bed The foot of the bed is raised about six inches When the patient is thus fixed there is often a considerable relief from pain, and with the aid of an overhead rope for his hands he can raise himself off the bed without pain and with little difficulty

In fractures without serious displacement the patient can be allowed to get up in about eight weeks but active movements of the lower limb are encouraged after the first month

In a case where one side of the pelvis is displaced upwards it will be necessary, under a general anæsthetic to pull it down by making firm manual traction on the leg in slight abduction while an assistant makes counter traction on the other half of the pelvis and body It will then be necessary to maintain a continuous strong pull on the leg and for this purpose a pin is put through the upper end of the tibia with a stirrup cord and weight attached, and the bed raised eight or ten inches

Recently Watson Jones has pointed out that the most usual displacement which occurs is a wide separation of the pubes with an outward and backward rotation of the os innominatum at the sacro iliac joint He has compared the typical displacement to a partly opened oyster and has demonstrated that with the patient on his back, reduction is difficult whereas if the patient be turned on to his uninjured side the displaced half of the pelvis tends to close up and reduction occurs spontaneously or quite easily with a little manual assistance

Reduction by this method is carried out under an anæsthetic and a plaster is applied to include the whole pelvis and both thighs as far as the knees The patient is subsequently nursed on his side for three weeks after which time the danger of redisplacement has usually passed and after a new well fitting plaster has been applied the ordinary position on the back can be resumed Plaster is kept on for three months and no weight bearing should be allowed until this period has elapsed

a fall on to the foot from a height there is a fracture anteriorly either through, or close to the symphysis pubis on one side and posteriorly close to the sacro-iliac joint on the same side the force transmitted through the leg to that side of the pelvis displaces the whole os innominatum upwards perhaps for as much as two inches In one case the giving way of a scaffolding caused two workmen to fall about forty feet They fell side by side one landing on his right foot and the other on his left The former had a separation and upward displacement of the right half of his pelvis and the other a separation and upward displacement of the left half and both had ruptures of the urethra

From the history of the accident and the tenderness and pain caused on attempting movements the diagnosis of a severe fracture of the pelvis is usually easy but it is sometimes quite remarkable how in the presence of other injuries a fracture of the pelvis may be overlooked even though it be borne in mind while examining the patient Skiagrams should settle any doubt though in a stout subject if the bone outline is not clear it is a wise precaution to have the X ray examination repeated

In a case where there is little or no displacement of the bones and the patient has not a feeling of insecurity as though he were coming apart it is sufficient treatment to keep him at rest in bed. The mattress must be supported on fracture boards so that it is quite level It is usually found to be possible to roll the patient on to one or other side for attention to the back. If the patient is heavy and awkward or has great pain on being moved, he may be treated as for the more severe cases of fracture of the pelvis described below

In some fractures of the pelvis where there is considerable discomfort the patient should be nursed in a pelvic sling A canvas sling ten to twelve inches broad is placed under the pelvis it must be long enough to reach well round and up the sides so that when the pelvis is suspended it keeps the two sides together it is attached by a cord to a weight and pulley suspended from an overhead beam A Thomas's splint is placed on each leg and with skin traction by ordinary strapping the legs are secured to the distal ends of

the bladder, in a few moments the lotion is allowed to run out through the catheter again and if none, or a less quantity than was run in is obtained, it is strong confirmation that the bladder is ruptured This test should only be carried out if operation can be immediately performed

*Operation* Though a spinal anæsthetic might seem desirable a general anæsthetic is often preferred owing to the difficulty of moving a patient with a fractured pelvis Through a midline supra pubic incision the bladder is exposed without opening the peritoneum If a rupture is seen all blood clot and urine in the extra vesical tissues must be swabbed out A finger is then put into the bladder and any rupture into the peritoneal cavity felt for The ragged edges are then trimmed off a tube is put into the bladder and as much of the tear as possible sewn up around it It is essential also to drain the peri vesical tissues very adequately Only in the rare cases where the tear is a clean straight line is it wise to suture the bladder completely without putting a tube into it

With an intra peritoneal rupture the same skin incision is used, as it is seldom possible to tell with certainty the type of rupture before operation If no extra peritoneal injury of the bladder is seen the peritoneum is opened, the tear into the bladder located and completely closed with two or three rows of sutures the peritoneal cavity is drained and a catheter tied in the urethra to prevent the bladder from becoming distended

Apart from the shock and other complications associated with any serious fracture the patient may succumb to peritonitis from an intra peritoneal rupture of the bladder or to pelvic cellulitis from an extra peritoneal tear

### (3) Fractures of the Acetabulum

A fracture of the pelvis may pass through the floor or roof of the acetabulum but the most significant fractures of this region are associated with displacement of the hip and will be described as Fracture-dislocation of that joint

## Treatment of Ruptured Urethra and Bladder

In every case of fracture the possibility of serious injury to the soft parts must be remembered. The urethra less commonly the bladder and very rarely the rectum may be torn. The urethra is injured in its membranous part as it is passing through the triangular ligament It may be slightly torn on one side though not sufficiently to interfere with the passage of a catheter or it may be torn across completely A catheter should be passed, and if it can be got into the bladder it should be tied in for ten days If the bladder cannot be reached with a catheter operation will be necessary When a complete rupture of the urethra is associated with a fractured pelvis it is better to drain the bladder by a supra pubic cystostomy than to attempt to reconstruct the urethra immediately The urethral repair is undertaken later either after some days or even weeks depending on the exact circumstances of the case

A rupture of the bladder may be either intra peritoneal or extra peritoneal. The latter is more common in association with a fractured pelvis The patient is unable to pass water and should not be encouraged to try Unlike a ruptured urethra, there is no difficulty in passing a catheter but when the latter has been passed no urine is obtained or at the most a very small quantity which is blood-stained. With an extra peritoneal rupture there is pain supra pubically and in the perineum though, of course this is rather masked by the pain of the fracture With an intra peritoneal rupture there is likely to be diffuse pain over the abdomen some rigidity and perhaps vomiting

A rupture of the bladder demands urgent operative treatment If there is doubt about the diagnosis a catheter may be passed and a few ounces of boracic lotion run into

anæsthetic is necessary, and it is important that deep anæsthesia is obtained, as not only will failure to reduce the dislocation occur under light anæsthesia, but the latter has the reputation of being dangerous when reducing dislocations At least one or preferably, two assistants are necessary The following manipulation is carried out With the patient lying on his back on a stretcher or mattress, placed on the floor one assistant kneels on the sound side and holds the pelvis securely with both hands so that it does not move during the manipulation The operator then flexes the hip and knee of the dislocated leg, holding the ankle with one hand and the lower part of the thigh with the other the hip is flexed fully and at the same time is adducted and internally rotated Then, by a process of forward lifting and circumduction it is externally rotated and abducted and brought down into the extended position, abduction being maintained until the last few degrees of extension have been carried out During the circumduction and further movements it is sometimes necessary to have a wedge or, preferably the fist of a second assistant placed under the great trochanter This acts as a fulcrum to lever the head over the posterior lip of the acetabulum into the joint

With anterior dislocations the procedure for reduction is similar except that the hip is flexed in abduction and external rotation it is then adducted and internally rotated, and from this latter position finally extended. After the dislocation has been reduced the patient is returned to bed with light traction on the leg in a slung Thomas s splint In about four weeks the splint is removed and active movements of the hip are encouraged in bed a gradual resumption of weight bearing can be allowed after six weeks

In the so-called irregular dislocations which are very rare and in which the Y-shaped ligament of Bigelow is torn the displacement is reduced by a manipulation which seems appropriate for the particular case The after treatment must be more prolonged than in the case of the regular dislocations and is most safely carried out by fixing the hip in plaster of Paris in slight flexion and abduction for six

## Chapter XVIII

# DISLOCATIONS OF THE HIP

Dislocation of the hip is an uncommon injury It is seen in young and middle-aged adults in whom the neck of the femur is strong In old people the neck of the femur is more likely to fracture than the hip to dislocate

A number of types have been described but no useful purpose is served here by enumerating them all and in describing them in detail. They have been divided into the regular and the irregular dislocations In the former the Y-shaped ligament of Bigelow remains intact whereas in the rare irregular group this ligament is torn

The commonest dislocation of the hip is that in which the head of the femur is displaced upwards and backwards on to the dorsum ilii in the sciatic type the head lies lower down over the sciatic foramen while in the anterior variety the head of the femur can be seen and felt in Scarpa s triangle with the femoral vessels raised up over it

The diagnosis of a dislocated hip is usually easy because the deformity of internal rotation with adduction and flexion which is present in the common dorsal dislocation is not found with any fracture This deformity combined with the shortening of the limb causes the ball of the great toe of the affected side to rest on the dorsum of the foot of the sound side There is great pain, which is often out of proportion to the degree of actual surgical shock which is present In the anterior dislocation the foot is externally instead of internally rotated. It is advisable to have an X ray examination before reducing the dislocation, both to confirm the diagnosis and to determine the presence or otherwise of any associated fracture Not infrequently the head of the femur breaks off a fragment of the rim of the acetabulum as it slips out of the socket

**Treatment** Except where there is severe shock, reduction should be carried out immediately A full general

anæsthetic is necessary, and it is important that deep anæsthesia is obtained, as not only will failure to reduce the dislocation occur under light anæsthesia, but the latter has the reputation of being dangerous when reducing dislocations At least one or preferably, two assistants are necessary The following manipulation is carried out With the patient lying on his back on a stretcher or mattress placed on the floor one assistant kneels on the sound side and holds the pelvis securely with both hands so that it does not move during the manipulation The operator then flexes the hip and knee of the dislocated leg holding the ankle with one hand and the lower part of the thigh with the other, the hip is flexed fully and at the same time is adducted and internally rotated Then, by a process of forward lifting and circumduction it is externally rotated and abducted and brought down into the extended position, abduction being maintained until the last few degrees of extension have been carried out During the circumduction and further movements it is sometimes necessary to have a wedge or preferably, the fist of a second assistant placed under the great trochanter This acts as a fulcrum to lever the head over the posterior lip of the acetabulum into the joint

With anterior dislocations the procedure for reduction is similar except that the hip is flexed in abduction and external rotation it is then adducted and internally rotated and from this latter position finally extended After the dislocation has been reduced the patient is returned to bed with light traction on the leg in a slung Thomas s splint In about four weeks the splint is removed and active movements of the hip are encouraged in bed a gradual resumption of weight bearing can be allowed after six weeks

In the so-called irregular dislocations which are very rare and in which the Y-shaped ligament of Bigelow is torn the displacement is reduced by a manipulation which seems appropriate for the particular case The after treatment must be more prolonged than in the case of the regular dislocations and is most safely carried out by fixing the hip in plaster of Paris in slight flexion and abduction for six

weeks After this movements are commenced but weight-bearing is not allowed for two and a half months from the time of the accident

## Fracture Dislocation

Fracture dislocations of the hip are of two main types—those due to the head of the femur being driven inwards and



FIG 54. Fracture of acetabulum with central dislocation of the hip. A blow on the great trochanter drives the head of the femur through the acetabulum into the pelvis. A subluxation of this type is more commonly seen than a complete dislocation, the head of the femur remaining in contact with part of the acetabulum.

causing a fracture of the floor of the acetabulum and those where some part of the rim of the acetabulum is broken off The former is often spoken of as a central dislocation of the hip but in the majority of cases it is a subluxation since the head of the femur is not completely separated from the articular surface of the acetabulum It is only rarely that the head of the femur is driven right through into the cavity of the pelvis where it may be felt per rectum

Fractures of the rim of the acetabulum are often associated with a posterior or anterior dislocation of the hip. The head of the femur as it leaves its socket breaks off a part of the rim. If this has not been diagnosed by X rays, it may be suspected if crepitus is felt as the dislocation of the hip is reduced.

Central dislocation or subluxation of the hip may be caused by a fall on the great trochanter or a severe crushing



FIG 55 Fracture-dislocation of hip, with fragment detached from rim of acetabulum.

accident. Posterior fracture-dislocations are often the result of a motor car accident. In a head-on crash the victim's knee strikes the dashboard of his own car and the head of the femur is forced violently backwards.

**Treatment** Central subluxation of the hip is treated by suspending the patient as described above for a fracture of the pelvis but the legs which must both be in Thomas's splints should be abducted to about forty five degrees. As it may be necessary to have a pull of fifteen or twenty pounds on the affected side a pin should be put through the tuberosity of the tibia as the skin will not permit of this amount of traction. If the traction is sufficient to hold the head of the femur so that it is in its correct position and

if this is maintained for at least six weeks, a hip joint with much better function than might be expected will be obtained When the patient gets up a well fitting weight-bearing caliper splint should be used for another three months

In the other type after reducing the dislocation of the hip in the ordinary way the limb should be immobilised for six weeks traction being maintained by a weight of eight to ten pounds on the limb

**Complications** Three important complications may follow dislocation and fracture-dislocation of the hip *The sciatic nerve* may be injured by the displaced head of the femur *Traumatic myositis ossificans* of the gluteal muscles may occur and produce considerable limitation of movement As the result of damage to its blood supply the head of the femur may undergo *avascular necrosis* This causes painful stiffness of the joint and leads to osteo-arthritis

## Chapter XIX

# FRACTURES OF THE FEMUR

(A) Fractures of the Upper End of the Femur
(1) Fractures of the Neck
(2) Per trochanteric Fractures
(3) Sub trochanteric Fractures
(4) Fractures of the Trochanters

(B) Fractures of the Shaft of the Femur

(C) Fractures of the Lower End of the Femur
(1) Supra-condylar Fractures
(2) T shaped Fractures
(3) Fractures of one Condyle
(4) Separation of the Epiphysis

## (A) Fractures of the Upper End of the Femur

(1) Fractures of the Neck From time to time the nomenclature of fractures of the neck of the femur has been changed The traditional names of intra-capsular and extra-capsular are not strictly accurate because the capsule covers the whole of the anterior surface of the neck but only reaches about half way along the posterior and thus the fracture line may be intra-capsular in front and extra-capsular behind Anyhow this differentiation has no clinical significance The only distinction necessary is between fractures of the neck and per trochanteric fractures Fractures of the neck of the femur have sometimes been divided into high or sub-capital fractures and low or basal fractures depending on the situation of the fracture line in the neck of the femur but it is far more important to notice the displacement of the distal fragment which may be either adducted and externally rotated or abducted not rotated at all but impacted Thus fractures of the neck of the femur may be "adduction fractures' or abduction fractures

The *adduction fracture* is the common fracture the majority of patients are over sixty and women are more frequently affected It often occurs from a trivial accident



FIG 50. Fracture of the neck of the femur; antero-posterior and lateral views. The femur has been outlined in the lateral view to demonstrate the amount of external rotation, (angulation convex forwards), which has occurred.

such as tripping down a stair or over a carpet or falling down on a slippery surface The patient is unable to rise from the ground and the limb is useless The degree of shock is generally much less than with a fracture of the shaft of the

femur The leg lies in a position of eversion, and though occasionally there may be a considerable degree of shortening it is rarely more than one inch The history of the accident and appearance of external rotation of the limb are so characteristic that diagnosis is usually easy

**Treatment** Although there have been great improvements in the management and treatment of these cases in recent years, a fracture of the neck of the femur must always be looked upon as a very serious injury Elderly patients often succumb to some other condition such as pneumonia uræmia or embolism It used to be noticed that non union was almost certain to occur, and because it was expected no proper attempt was made to fix the fragments securely and the expected result almost invariably followed With modern treatment however bony union is obtained in a high percentage of the cases As soon as the diagnosis is made the patient's general condition particularly as regards the chest and kidneys should be determined. If she is old and very feeble and considered unsuitable for any form of treatment no attempt is made to obtain bony union she is sat up in bed with her legs steadied between sandbags, but is not allowed to remain in bed too long for fear of becoming completely bedridden She may be taken out in an invalid-chair or helped to walk with crutches

The more that is seen of the two chief modern methods of treatment the more it is realised how well many old patients stand radical treatment for a fracture of the neck of the femur and in the majority of patients bony union can be obtained in this type of fracture even in patients over seventy

The two methods of treatment in use at the present time are

(1) Reduction of the fracture followed by immobilisation in plaster

(2) The insertion of a Smith Petersen nail

The second of these methods is definitely preferred to the first, as it not only gives a greater likelihood of bony union occurring but allows the patient more freedom than when encased in plaster of Paris The shock and strain on the

patient is not appreciably greater when a nail is inserted into the neck of the femur than when a plaster is put on.

When the facilities or ability for putting in a nail are not available then a plaster should be put on Also when there is any local or general sepsis a nail must not be used

A word must be said about the use of X rays in the treatment of fractures of the neck of the femur Although sometimes only an antero posterior view of the femoral neck is taken, it is essential to have a lateral view if the position of the fragments following reduction is to be properly checked An antero posterior view may be sufficient for diagnostic purposes but is quite inadequate for telling the exact relation of one fragment to another Stereoscopic views in this region are a poor substitute

(1) *Reduction followed by Fixation in Plaster* This method was described and advocated by Whitman. If the patient is fit to stand an anæsthetic which is necessary he should be safely able to undergo the manipulation and fixation in plaster

It is advisable to wait for twenty four hours after the accident before proceeding with treatment Under a general or spinal anæsthetic the patient is placed on some form of orthopædic table and reduction is carried out by making powerful traction in the long axis of the limb followed by full abduction and internal rotation Reduction is often easier if the procedure suggested by Leadbetter is adopted. By his method traction is first exerted with the thigh flexed to a right angle at the hip joint and the knee bent The limb is thus lifted up rotated inwards and is abducted as the leg is gradually allowed to come down to the extended position Provided X rays then show that the fragments are in position the limb is immobilised in plaster A plaster hip spica is put on over dressmaker s wool which is used as padding In order to steady the pelvis and lower part of the trunk it is often advised that the opposite leg as far as the knee should be encased in plaster but this is not necessary if the plaster is carried well up on to the lower part of the

chest on the sound side The knee should be slightly flexed, because it is a more comfortable position as well as helping to maintain the internal rotation at the hip Below, the plaster should reach to the toes as it is more comfortable if the foot is included than if the plaster ends just above the ankle The plaster should be reinforced across the level of the hip joint anteriorly and across the sacrum behind as these are the places where it is most likely to break The best way to reinforce a plaster hip spica is with slabs of plaster rather than with metal or wooden strips After a few days the patient may be got out of bed and placed in a semi-sitting position in a large armchair or on a couch



FIG. 57 The Smith Petersen Nail with central cannula. A modification which is not always used is a pin which can be passed through the head of the nail into the cortex of the shaft of the femur and provides additional fixation.

Provided the X rays show that the fragments are in good position this plaster should be left on for three months When it is removed the patient is encouraged to practise movements at the hip and knee of the two the knee is often the more stiff and painful. As soon as the patient has regained good muscular control of the limb progressive weight bearing is permitted at first with the aid of crutches

Many excellent results are obtained by this method of treatment, and bony union with a good functional result may be expected in about 60 per cent of cases

(2) *The Insertion of a Smith Petersen Nail* Although many methods of immobilising the fractured surfaces of the head and neck of the femur had been previously suggested, Smith Petersen produced a revolutionary change in the

treatment of fractures of the neck of the femur by introducing the three-flanged nail Tibial grafts beef bone and ivory pegs metal screws wires and nails had all been used before but had all failed because they became loose as a result of bone absorption round them and ceased to hold the fracture securely The tri radiate shape of the Smith Petersen nail ensures that although the channel in the bone along which the nail has been inserted may become enlarged as a result of absorption its shape remains unaltered and consequently rotatory movement is eliminated In addition by making his nail of stainless steel Smith Petersen probably reduced the amount of absorption of bone which occurred

An important modification of the Smith Petersen nail which has been introduced since its inception is a hole throughout its length for the introduction of a guiding wire The nail was originally introduced by an open operation in which the hip joint was opened and the fracture exposed This open operation is not used nowadays and the nail is always introduced through a small lateral incision over the shaft of the femur into the bone at the junction of the great trochanter and the shaft Through this incision a guide is first put into the bone and if antero-posterior and lateral X rays show the position to be correct then the nail is hammered into position along the guide and the latter is withdrawn Many techniques and pieces of apparatus have been devised for the correct placing of the guide but as the proper insertion of a Smith Petersen nail is a very specialised procedure the details are not given in this book

A Smith Petersen nail holds the head very securely in position on the neck so that it is actually possible for weight to be borne immediately and for the patient to walk. This is however not advisable as after a short time the head is likely to move In the after treatment movements of the hip with the help of a masseuse should be started two weeks after operation knee movements having been started immediately after the operation The patient may sit up in bed and at the end of four weeks sit in a chair but weight should not be taken on the leg for at least three



FIG. 58. Another fracture of the neck of the femur after reduction and nailing.

months During the first month following the operation care must be taken to prevent the leg becoming externally rotated

Provided a Smith Petersen nail is well placed and no

treatment of fractures of the neck of the femur by introducing the three flanged nail. Tibial grafts beef bone and ivory pegs metal screws wires and nails had all been used before but had all failed because they became loose as a result of bone absorption round them, and ceased to hold the fracture securely The tri radiate shape of the Smith Petersen nail ensures that although the channel in the bone along which the nail has been inserted may become enlarged as a result of absorption its shape remains unaltered and consequently rotatory movement is eliminated. In addition by making his nail of stainless steel Smith Petersen probably reduced the amount of absorption of bone which occurred.

An important modification of the Smith Petersen nail which has been introduced since its inception is a hole throughout its length for the introduction of a guiding wire The nail was originally introduced by an open operation in which the hip joint was opened and the fracture exposed This open operation is not used nowadays and the nail is always introduced through a small lateral incision over the shaft of the femur into the bone at the junction of the great trochanter and the shaft Through this incision a guide is first put into the bone and if antero-posterior and lateral X rays show the position to be correct then the nail is hammered into position along the guide and the latter is withdrawn. Many techniques and pieces of apparatus have been devised for the correct placing of the guide but as the proper insertion of a Smith Petersen nail is a very specialised procedure the details are not given in this book

A Smith Petersen nail holds the head very securely in position on the neck so that it is actually possible for weight to be borne immediately and for the patient to walk. This is however not advisable as after a short time the head is likely to move In the after treatment movements of the hip with the help of a masseuse should be started two weeks after operation knee movements having been started immediately after the operation The patient may sit up in bed and at the end of four weeks sit in a chair but weight should not be taken on the leg for at least three



Fig 59. Pertrochanteric fracture of the femur The fracture runs obliquely from the region of the greater to the lesser trochanter



Fig 60 Fracture shown in Fig 59 after reduction.

of this shortening and the adduction deformity the patient will walk with a very ugly limp As a result of comminution there may be considerable splintering at the junction of the neck and great trochanter and of the upper outer edge of the shaft of the femur

unusual complication occurs bony union will be obtained in most cases

*In old ununited fractures of the neck of the femur* the line of treatment depends largely on the condition of the patients If old and infirm they should be taught to walk about with the aid of sticks or crutches with those in better condition but not fit for a big operation great help may be obtained from wearing a Thomas s caliper splint In fit subjects if the non union is of fairly recent date and the fragments are not showing undue rarefaction or sclerosis a Smith Petersen nail may be put in with a reasonable chance of union occurring

In other cases the choice lies between

(*a*) Doing a subtrochanteric osteotomy followed by abduction of the leg and
(*b*) Removing the femoral head rounding off the femoral neck and moving the great trochanter further down the shaft

*Abduction* fractures are uncommon and since they are impacted the patient may to able to walk following the injury The fracture does not require reduction and will unite satisfactorily if a plaster spica for the hip is applied but the insertion of a Smith Petersen nail is a better method of treatment

(2) PER TROCHANTERIC FRACTURES The line of fracture in these cases is somewhat variable and comminution is often present The fracture runs down obliquely through the great trochanter and reaches the inner side of the shaft at its upper end in the region of the lesser trochanter It is seen most frequently in old people though it may occur at any age

**Treatment** Depends on whether the fragments are displaced and on the degree of comminution.

If there is any displacement the shaft of the femur is adducted and externally rotated Every effort should be made to overcome this deformity because if the shaft of the femur is allowed to unite to the neck in an adducted position there will be considerable shortening of the limb Because

down the affected leg and pushing the other upwards the pelvis is tilted and the injured limb becomes relatively more and more abducted although in fact the legs remain parallel because the uninjured limb adducts at its hip joint If the legs are locked in position by a cross bar between the feet none of the patients movements will alter the angle of abduction of the fractured limb or the angle of adduction of the other Traction on the injured leg is maintained by counter pressure against the sole of the foot of the well leg Once the legs have been fixed in this manner the

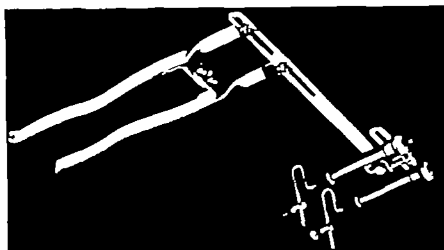


FIG 61. Photograph of the "well leg" traction splint designed by Roger Anderson.

patient can sit up and lie down because flexion and extension at the ball and socket hip joint occur without altering the angle of abduction and adduction which each limb makes with the pelvis This ability to sit and move comparatively freely in bed is the great advantage which this method shares with operative fixation in the treatment of these fractures which more often than not occur in the aged

In practice a plaster cast is applied to the sound leg which includes the foot and extends above the knee The sole of the foot and the tibial tuberosities will have to withstand pressure so both must be well padded with felt A cast on the injured leg extends from the metatarsal heads to just

In a good many cases there is no displacement between the proximal and distal fragments so that the angle which the neck of the femur makes with the shaft remains un altered. In these circumstances it is unnecessary to do more than nurse the patient carefully in bed. After the first few days he or she may be allowed to sit up in bed, and after the first two weeks it is safe to begin assisted exercises for the hip joint and knee The position of the fracture must be reviewed by X ray examination every week for the first month in case some displacement has occurred, but it is unusual for this to happen. At the end of a month the fracture is usually firm enough for the patient to be allowed to move about freely in bed and to continue to exercise the hip and especially the knee Most of these fractures are united in eight weeks and the patient can then get up with crutches not putting weight on the injured limb for a further month

In those cases in which there is adduction and external rotation deformity but very little if any comminution, the injury is treated on the same lines as a fracture of the neck of the femur After reduction of the displacement under anaesthetic and with X ray control, a Smith Petersen nail is introduced across the fracture line into the neck of the femur The technique of insertion is a little different A longer nail is used and it is directed more obliquely but the principles of the method and the after treatment are the same

If there is comminution as well as displacement a Smith Petersen nail will not hold in the fragments For this more difficult situation a special nail has been devised which has a plate attached to the head at an angle The nail which is of modified Smith Petersen type is inserted in the usual way this brings the plate in place on the outer surface of the shaft of the femur down which it extends for two or three inches and to which it is secured by screws

In order to deal with these difficult displaced or displaced and comminuted per trochanteric fractures by a non operative method Roger Anderson evolved his well leg *traction splint* The principle invoked is simple By pulling

lower end of the tibia on the affected side and included in the cast Traction is exerted by an adjustable spring and the legs are fastened together by a metal crosspiece

During treatment by the well leg traction method the position of the fracture must be frequently reviewed by X ray

These fractures may be slow in uniting and are unlikely to be firm in less than three months It is unfortunately impossible for the patient to carry out knee movements while the splint is in position and stiffness is often trouble some Regular static exercises for the quadriceps muscle will go a long way to mitigate this complication.

(3) SUB TROCHANTERIC FRACTURES The injury occurs at the level of the lesser trochanter The fracture is oblique and may run upwards from within outwards or downwards from within outwards In both types of fracture the deformity is one of adduction of the lower fragment but when the fracture line runs downwards from within out wards the distal fragment may be drawn upwards to the inner side of the proximal fragment with progressive shortening of the limb

**Treatment** In those cases where the shaft of the femur is adducted but the fracture line runs upwards from within outwards the deformity can be reduced by abduction of the limb under anæsthetic The fracture is quite stable and the fragments can be maintained in good position by means of a plaster double hip spica which includes the foot on the injured side but extends only as far as the knee on the opposite limb Union will take place usually in about eight weeks The plaster can then be removed for knee exercises but the bone will not be strong enough to take the weight of the body for at least another month.

When the line of fracture runs downwards from within outwards, at first there may not be any shortening but this type of fracture is unstable and simple immobilisation in plaster will not suffice Traction on the limb is absolutely essential to prevent a possible deformity or to correct shortening and adduction if already present The well leg traction splint already described in the treatment of per

below the knee With the patient lying supine and, if necessary under anæsthetic the fractured limb is pulled down and the uninjured pushed up until the required angle of abduction has been achieved. The two casts are then

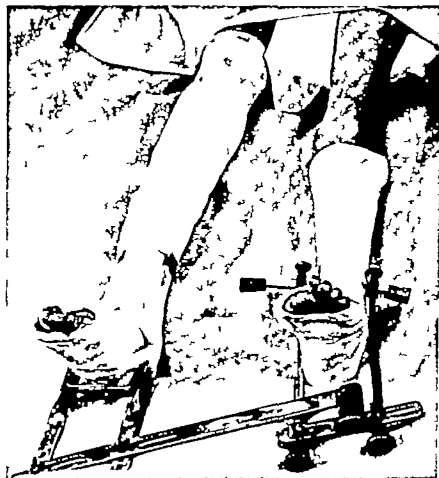


FIG 62. The patient with a per trochanteric fracture whose X rays are shown in Fig 59 and Fig 60 showing the "well leg" traction splint in use.

secured to each other by bent Kramer wire extending transversely between the legs and joining the sole of each foot Instead of Kramer wire the actual splint described by Roger Anderson (see Fig 61) may be used. The metal side bars of this splint are incorporated in the plaster cast on the sound limb A Steinmann's pin is driven through the

degree of shock which is often present with simple closed fractures of the shaft of the femur Fractures of the shaft of the femur are associated with more shock than fractures of any other bone in the body, the explanation for this may be that there is extensive injury to the large mass of surrounding muscles and hæmorrhage

On examination the thigh is very swollen and tense often being twice the size of the sound side shortening which may be as much as three or four inches is present The limb distal to the fracture is externally rotated as is readily seen by the foot lying over on its outer side On raising the limb abnormal mobility at the site of fracture is obvious The diagnosis is usually easy from the history and from the pain and other signs described above but it is not by any means so easy to say at exactly what level the shaft is broken though deformity may be present and abnormal mobility demonstrated an error of five or six inches in the level of fracture may easily be made It is therefore always a wise precaution to have a skiagram taken of the *whole* length of the shaft of the femur

Though the displacement of the fragments largely depends on the direction of the fracturing force, the characteristic displacements of fractures at three different levels in the shaft will be mentioned With fractures in the upper third the proximal fragment is flexed abducted and everted by the muscles attached to the trochanters so that the distal fragment lies behind it With a fracture just below the middle of the shaft the proximal fragment is often found to be adducted This is due to the pull of the adductors and if not present at first this deformity is likely to occur when traction is made on the limb for then that side of the pelvis is tilted downwards so that the hip is abducted thus causing greater tension on the adductors This will be referred to again under *treatment* but it will be obvious at this stage that if the pelvis is kept level by traction being made on the sound as well as on the fractured leg the pull of the adductors is not likely to be so great In the lower third of the femur the chief deformity is one of flexion of the distal fragment so that the lower end of the proximal

trochanteric fractures is very satisfactory for the unstable sub trochanteric fractures

The unstable fractures take longer to unite than the stable type Union is unlikely to be present in less than three months and it may be *four months* before walking can be allowed without crutches

Well leg traction is the method of choice for all sub-trochanteric fractures in old people

In describing the treatment of per trochanteric and sub-trochanteric fractures the Thomas splint has not been mentioned. This splint was not designed for the treatment of fractures of the femur occurring near the hip joint and it is quite ineffective for this purpose

(4) (*a*) Fractures of the Great Trochanter. The great trochanter alone is not often fractured though as a rare accident in young people it has been known to be separated. The great trochanter is involved in trans trochanteric fractures and it may be broadened in extra capsular fractures of the neck of the femur when the latter is impacted into it

(4) (*b*) Fractures of the Lesser Trochanter By the muscular pull of the psoas the lesser trochanter may be separated and pulled upwards This condition is usually seen only in young persons before the lesser trochanter has united with the shaft Although the separated fragment cannot be replaced perfectly by manipulation open operation is not required as by treating the patient with the hip in full flexion for a fortnight and then allowing gradual extension a perfect functional result is obtained Vigorous games should be prohibited for two months

## (B) Fractures of the Shaft of the Femur

The shaft of the femur may be fractured in any part of its length by an injury which may be direct or indirect In the former the fracture is usually transverse while in the latter it is oblique or spiral. The fracture is often comminuted, but very rarely impacted Associated nerve injuries are uncommon and in civil practice the majority of cases are closed fractures

Due regard must always be paid to the considerable

cribed a patient with a fracture of the shaft of the femur may be transported for some distance without fear of further damage being done to the leg and without further increasing the shock. It is not advisable to continue this temporary splinting for more than a few hours in case damage to the foot may result from pressure.

Only in exceptional circumstances is a fracture of the femur immobilised by any other means than continuous traction. As soon as possible after the accident the fracture should be reduced and put up with traction.

The principles of all the methods of treatment of fractures of the femur by traction are the same. Many modifications in the application of the principles and in the actual splints used have been tried. Traction may be obtained either from the skin or directly from the bone. Except in children, or where local or general sepsis is present, skeletal traction is to be preferred to a continuous pull on the skin, particularly if a weight of over twelve pounds is used. With children such a weight is not needed and skin traction is satisfactory; with skeletal traction in children there is danger of injuring epiphyses and cutting through the soft bone. In adults skeletal traction may be obtained by pins or wires. A strong Steinmann's pin driven right through the bone has the advantage that it remains secure, will not come out, and will not bend. A Kirschner wire has the advantage that it makes a smaller hole than a pin, but has the disadvantages that a special drill is required for its introduction, a strainer to keep the wire taut is necessary, and it is not unknown for a wire to break. Pins and wires have entirely replaced the use of ice tong calipers.

To obtain traction on a fractured femur a pin may be passed through the tubercle of the tibia. Some surgeons pass the pin through the lower end of the femur about three-quarters of an inch above and anterior to the adductor tubercle. When the latter situation is used it may be an advantage that a more secure and direct hold is obtained on the distal fragment, but many dislike putting the pin here because of the danger of injuring the lateral expansions of the synovial membrane of the knee joint if the pin is too

fragment as the result of the overlapping often lies directly in front of it The deformity is maintained by the pull of the gastrocnemii

**Treatment** With all fractures first-aid treatment is important but in none is it more so than with fractures of the femur Shock is always prominent and must be treated immediately and if proper first-aid splinting of the fracture is not carried out shock will be greatly aggravated by pain and by further injury to the soft issues

The best first aid method for transport of a patient with a fractured femur requires a Thomas s splint with a rather large ring a stout skewer a support for fixing the splint to the stretcher as well as a supply of bandages etc The patient s clothes are not removed, nor is his boot the limb is lifted, not by placing hands under the fracture but by pulling powerfully on the ankle so that the limb is extended sufficiently to prevent angulation at the fracture as it is lifted The large-ringed Thomas s splint is slipped over the boot and pulled up over the trousers so that it comes well up to the ischial tuberosity It is necessary to maintain traction while the patient is transported, and many ways have been devised for doing this If the patient has a large strong well fitting boot the most satisfactory method is to push a strong skewer through the instep of the boot so that it goes between the sole and the upper Cords are then attached to each end of the skewer and tied firmly over the end of the splint by this means the pull is distributed fairly evenly over the foot by the boot and is not so likely to cause pressure sores as some other methods The whole length of the thigh and calf must be supported behind by slings and bandages which pass from one side-bar of the splint to the other these are best fixed by safety pins A large encircling bandage further secures the leg to the splint Counter traction is made against the ischial tuberosity but a large ring may ride up so that it rests against the pubic bone over which a pad should be placed With the femur thus extended the pain disappears and it remains only to secure the splint to the stretcher With the administration of a quarter of a grain of morphia and the leg fixed as des

a foot piece may be attached to the knee flexion iron or the foot may be supported from a pulley and weight by two strips of adhesive strapping, one along the sole and up behind the heel and the other on the dorsum of the foot, both are secured by elastoplast around the foot With this method of fixation *the patient is able to move the foot* and ankle freely, but at the same time foot-drop is prevented The *knee is kept flexed because it is uncomfortable if it* remains absolutely straight for any length of time but the degree of flexion will vary according to the level of the fracture and the nature of the displacement of the fragments The position of the hip differs also according to the level of the fracture and the direction of the displacement this immediately leads to the disputed question of whether the sound leg should be abducted in a Thomas s splint or not With a fracture in the upper third of the shaft of the femur where the proximal fragment is flexed abducted and some what externally rotated it is necessary according to the first rules of the treatment of fractures to put the limb *i e* the distal fragment in the same position of abduction and flexion Because the proximal fragment is abducted by muscles it does not matter in what position the pelvis is, provided the two fragments of the femur are in proper alignment so that it is not necessary to immobilise the sound leg in the case of fractures of the upper third of the shaft of the femur

With fractures in the middle third or at the junction between this and the lower third the proximal fragment lies midway between abduction and adduction but may be slightly flexed in which case the distal fragment must be put in alignment *i e* with the leg straight down the bed When traction is applied to one leg in this position the pull causes the pelvis on that side to be tilted downwards this *means that the hip is abducted* and the adductor muscles are stretched and the latter sometimes cause the proximal fragment to be adducted If this is not corrected and union takes place in this position an awkward deformity will occur This may be prevented either (*a*) by arranging a lateral pull or push to correct the inward displacement of the

far forward or of injuring the popliteal vessels if it is too far back A pin put through the tubercle of the tibia is not likely to damage important vessels or nerves The objection that the ligaments of the knee joint are stretched by traction on the tubercle of the tibia with a fractured femur is not borne out either in practice or in theory A certain degree of stiff ness of the knee rather than a loosening from stretching of ligaments is found also a moment s consideration makes it obvious that there is little tendency to drag the tibia away from the distal fragment of the femur since the shaft of the femur is fractured and all the muscles of the thigh, except the adductors longus and brevis are attached either directly or indirectly to the tibia and fibula and not to the distal half of the femur

*Technique of applying Traction* The patient is given a general anæsthetic and when he is unconscious the trousers are removed and the whole leg thoroughly cleaned. A Thomas s splint is then slid up over the leg its ring need not fit tightly, but a very large ring is inconvenient The next step is to insert a Steinmann s pin or Kirschner wire *through the tibia at the level of the tuberosity* this must always be done with careful aseptic precautions The skin is cleaned and painted with antiseptic and the operator must wear mask, gown and gloves A stirrup is fixed to the pin and from this a cord runs over a pulley to a twenty pound weight both ends of the Thomas s splint are suspended from an overhead beam and a knee-flexion piece is added and fixed so as to hold the knee at an angle of about 160 degrees the foot of the bed is raised about twelve inches Two further points must not be neglected with a leg secured thus in a Thomas s splint there is nothing to prevent the splint from sliding down the leg so that the ring is some distance from the ischial tuberosity this is very easily prevented by a short piece of cord which runs from the stirrup of the Steinmann s pin to the end of the Thomas s splint This in no way interferes with the mechanics of the traction, and, though not always necessary is a wise precaution against *shifting* of the splint The foot must be supported in some way

experienced sister If the fracture has been treated as described with the knee bent it is particularly important to regain the power and full range of extension at the knee joint before increasing the range of flexion

The leg should be kept on the Thomas s splint until the fracture as shown by clinical and X ray examinations, has united. Judging by these is a matter of experience but if in doubt it is better to leave the fracture up a week or two longer because if taken down too soon deformity may recur A long oblique fracture is usually sufficiently united to remove the splint and allow the patient to kick the leg about in bed in ten weeks whereas with a transverse fracture twelve or more weeks may be required

After a fracture of the femur has been treated the knee is likely to be stiff—at least, for a time As already described knee movements are commenced at the end of the sixth week but it is most important to see that when the patient is walking about knee movements are continued four times a day Quadriceps exercises are necessary throughout the whole period of treatment

Occasionally a well fitting caliper splint may be necessary It must be emphasised that a caliper splint is worse than use less if it does not fit properly and really take the patient's weight off the leg The caliper should be half an inch longer than the leg so that when the ring of the splint is firm against the ischial tuberosity the patient s own heel is definitely separ ated from the heel of the boot The length of time necessary for wearing a caliper splint is dependent on the patient s age and weight as well as on the type of fracture—whether oblique transverse comminuted, open, etc Up to nine months is a usual length of time for the splint to be worn but four to six months is often sufficient in young adults with an oblique fracture

*Treatment of Fracture of the Shaft of the Femur in Children* Over the age of six or a little younger if the child is big treatment is similar to that in an adult But it is usually easier because many of the fractures are either green-stick or with but little displacement and often oblique Treat ment is also easier because the power of the muscles is so

proximal fragment, or (*b*) by applying traction to the sound limb The latter will correct tilting of the pelvis and thus relax the adductors and it is sometimes striking how the bones will come easily into alignment Therefore with fractures in the region of the junction between the middle and lower thirds of the shaft it is usually advisable to put *the sound leg in a Thomas s splint and apply skin traction* with about twelve pounds weight If there is any backward displacement of the distal fragment this may be corrected, once the leg has been pulled down to its full length, by flexing the knee a little more or by suitable padding

To correct the posterior displacement of the distal frag *ment in fractures of the lower third of the femur it may be* necessary to flex the knee further after traction has been applied. If this is not successful the deformity may be overcome by making the point of flexion in the splint three or four inches higher up than the knee this is easily done by sliding the knee flexing iron upwards on the main splint and by placing a large pad under the site of fracture

If displacement is not completely corrected when the Thomas s splint is put on, it must be seen that proper reduction of the deformity is obtained as soon as possible and always within seven days of the injury This must be controlled by X rays and films should be taken daily until a satisfactory *position is obtained.*

From the beginning the patient is encouraged to move his ankle foot and toes several times a day and to contract his quadricep muscles The leg splint cords and pulleys must all be inspected daily The leg should be measured each day to see that shortening has not recurred, or on the other hand *that it has not been pulled out too far skiagrams should be* taken weekly In the first weeks of treating a fractured femur a great deal of close personal supervision is required. If all has gone well union of the fracture will be firm enough by the end of six weeks after reduction for movements of the knee to be allowed The pin is removed and replaced by strapping extension applied to the leg this permits active flexion and extension exercises for the knee to be carried out four times a day under the supervision of a masseuse or

fragment The lower end of the proximal fragment may appear as a bony prominence just above the patella

**Treatment** This may be one of the most difficult of fractures to reduce, but every effort must be made to obtain a good position or severe crippling will result With the muscles fully relaxed under anæsthesia it is sometimes possible to reduce the fracture by manual traction and manipulation Occasionally the fragments will lock together so that displacement does not tend to recur, but more often they slide apart and it is necessary to maintain continuous traction by a pin through the tubercle of the tibia with the leg suspended in a Thomas's splint (see Fractures of the Shaft of the Femur page 192) The knee should be flexed at an angle of about 135 degrees A Braun s splint may often be used with advantage in the treatment of this fracture Union occurs readily as is the rule with fractures at the ends of long bones and traction can often be removed at the end of four weeks and the leg taken down after six

(2) T-SHAPED FRACTURE This is a further degree of the supra-condylar fracture the lower end of the shaft of the femur being driven down and separating the condyles from each other The displacement may be slight or the condyles may be separated far apart with the lower end of the shaft between them. There is always considerable effusion of blood into the knee joint and injury to the main vessels' and nerves may occur

**Treatment** When there is little or no displacement the leg should be immobilised in a Thomas s splint with the knee flexed at about 135 degrees If there is much displacement it will be found difficult to reduce the fracture, if so the leg is placed in a Thomas s splint and, by a pin through the tubercle of the tibia a weight of thirty or forty pounds is attached If the knee is distended with blood it should be aspirated In twelve to twenty four hours the limb will probably be pulled out to its full length, when the separated condyles must be pressed together and the weight reduced This may be done manually or, if sufficient power cannot be obtained by the hands a piece of felt should be placed at each side of the condyles and the two compressed together

much less It is possible to obtain a sufficient pull by skin traction in children and it is always to be preferred to skeletal traction, which may be dangerous If the latter is necessary it is unwise to put a pin or wire through the lower end of the femur the tuberosity of the tibia is to be preferred.

In younger children it is better to use a gallows splint Both legs are fixed in the 'gallows which holds the legs suspended vertically in the air with the hips flexed to a right angle Adhesive strapping extension is applied to both legs and the strapping fixed to a wooden stirrup which is attached to the horizontal bar of the 'gallows' by a cord. The cords from each leg may be fixed either rigidly or over pulleys to weights In either case they are so arranged that the buttocks are just raised off the bed Children soon get accustomed to and appear comfortable in, this position and the nursing is made easy The fracture in nearly all cases will be found to reduce itself and remain in good position. After four to six weeks union is usually strong enough to allow the child to kick about in bed and by the end of eight weeks provided X rays show well-defined callus, it is safe to let the child walk without any splint

Fractures of the femur without displacement in young children are often effectively treated by means of a plaster double hip spica The plaster includes the whole of the affected limb

## (C) Fractures of the Lower End of the Femur

(1) Supra-condylar Fractures The line of fracture is approximately transverse immediately above the con dyles in the region of the adductor tubercle The distal fragment is displaced behind the lower end of the proximal fragment and tilted backwards This displacement is mainly due to the direction of the fracturing force but partly to the pull of the gastrocnemii which flex the separated distal end of the femur on the tibia Careful observation of the condition of the circulation in the distal part of the limb should be made because the popliteal vessels are sometimes compressed by the displaced distal

plaster is contra indicated a Thomas's splint with a lateral band holding the knee in the corrected position may be used After six weeks the plaster is removed knee movements are begun and a caliper splint is fitted It is essential to have a strap at the knee to hold the latter in the correct position to prevent upward pressure on the fractured femoral condyle—*e.g* with a fracture of the external condyle the strap must pull the knee towards the iron on the outer side The caliper should be worn for six months Upward displacement is more likely to occur, and is more troublesome with a fracture of the outer than of the inner condyle and the resulting deformity of the former, *i.e* knock knee is more disabling than a bow leg

Provided satisfactory reduction of the fracture has been effected good function of the knee joint both as regards movement and stability should follow

Occasionally reduction by this method is not successful and it may be necessary to expose the fracture by open operation The incision should be kept fairly well posterior on the inner or outer side as the case may be the fragment exposed and levered into position and, if necessary fixed with a long screw A screw will not hold it absolutely securely and as much care must be taken to prevent a recurrence of the displacement as in the cases treated only by manipulative methods

(4) Separation of the Epiphysis Separation of the epiphysis at the lower end of the femur though uncommon may result from a direct or indirect injury it has been recorded as having occurred during manipulation of the knee for joint stiffness The displacement is the opposite to that which occurs in a supra-condylar fracture the epiphysis being displaced *forwards* In severe cases the lower end of the proximal fragment projects into the popliteal fossa and may press on and interfere with the circulation in the popliteal vessels it is therefore always important to note the condition of the circulation in the distal part of the limb

Treatment Under an anæsthetic the epiphysis is manipulated back into correct alignment If it should not be possible by ordinary manual manipulation, it may be of help

with a clamp A special compression clamp is obtainable for use in fracture work but an ordinary carpenter's wooden clamp is equally effective and costs but a few shillings It is not safe to continue the clamp pressure and if the condyles show a tendency to separate a firm bandage over wool or a few turns of elastoplast will be sufficient to hold them together Gentle controlled, active movements may be begun after six weeks and in eight to ten weeks the limb may be removed from the splint A weight bearing caliper splint will be necessary for about six months The end result depends largely on the accuracy of the reduction but in most cases there is limitation of flexion to about 90 degrees

(3) Fractures of One Condyle. Either condyle may be separated and the fracture as a rule runs obliquely upwards from the intercondylar notch to the inner or outer side of the femur as the case may be

Displacement is always upwards and if this is not completely corrected a genu valgum or varum will result

The outer condyle of the femur is a common situation for a benign giant cell tumour (osteoclastoma) On a number of occasions a pathological fracture has been seen through the outer condyle which was the site of such a tumour The true state of affairs may be overlooked at first and treatment undertaken for the fracture while the tumour continues to increase in size

**Treatment.** It is essential to correct completely the upward displacement of the separated condyle Under a general anæsthetic and with the knee straight any upward displacement of the condyle is corrected by abducting or adducting the tibia on the femur depending upon whether it is the inner or the outer condyle that is separated This movement of the tibia will drag the condyle down into position through the pull of the corresponding collateral ligament It is so important to correct the displacement fully and *over-correction is so unlikely to occur that it is* advisable to fix the limb with the tibia slightly over-corrected in relation to the femur The best method is to fix the leg in a plaster cast extending from the toes to the groin. If there is any injury to the skin or if for any other reason

CHAPTER XX

# FRACTURES OF THE PATELLA AND DISLOCATIONS OF THE KNEE

## Fractures of the Patella

THE patella is most commonly fractured by indirect violence due to muscular pull though occasionally from a direct blow on the bone

As a person stumbles forward the quadriceps gives a



FIG 63 Fractured patella. Typical transverse fracture of the patella with separation The proximal fragment is drawn up by the quadriceps muscle.

to have an assistant pulling firmly on the limb so as to separate the epiphysis from the lower end of the shaft, and then by the aid of a wedge under the lower part of the shaft the epiphysis can usually be replaced. There is a liability for the epiphysis to slip forwards again, and this is best prevented by immobilisation of the leg with the knee flexed to about 90 degrees A Thomas s splint or plaster of Paris cast can be used and unless there is any anxiety about the skin or the circulation of the limb the latter is preferable the plaster should reach from the toes to the groin. After four weeks the plaster should be removed and the knee gradually straightened. X rays should be taken to make sure that displacement does not recur At first it is rather stiff but in a few days full extension can usually be obtained At the end of six weeks the patient is allowed to walk.

Provided reduction of the deformity is satisfactory, there should be a perfect functional result the initial stiffness of the knee soon wears off and there is rarely any interference with growth of the bone

which is almost invariably found between the fragments and to fix the fragments in apposition

(2) To repair the lateral expansions of the quadriceps

A great variety of methods of fixing the bone has been employed—silk catgut wire kangaroo tendon and fascia lata have all been used A simple and very satisfactory operation for suturing a fractured patella is as follows An incision starting about an inch below and to the inner side of the patella sweeping across in front of the ligamentum patellæ and up the outer side of the thigh for about ten inches, is made a flap is then turned up exposing both fragments of the patella and on the outer side of the thigh the fascia lata is exposed The flap of aponeurosis of the quadriceps is lifted out from between the two fragments and all blood clot removed from the joint which is widely open A strip of fascia lata about nine inches long and one-third of an inch wide is cut but is left attached to the tibia below this strip is then made to encircle the patella This is easily done by passing a fairly sharp pair of artery forceps from the medial to the lateral side through the quadriceps tendon immediately above the patella The strip is seized by the forceps and pulled through the tendon. A forceps is then passed through the ligamentum patellæ from without inwards immediately below the patella and the strip of fascia lata is grasped and pulled through. The fragments of the patella are adjusted in position and the strip of fascia encircling it drawn tight and stitched to itself with fine silk at a point a short distance above the tibia The aponeurosis of the quadriceps should then be stitched down with catgut and the lateral expansions of the capsule of the joint which are usually torn must also be securely sutured The skin is then closed

*After-treatment* The leg is put in a padded plaster for ten days when the stitches are removed and the leg from the ankle to the groin is immobilised in a well fitting unpadded plaster cast This should be kept on for a month after the operation but the patient may walk about At the end of that time the plaster cast is replaced by a plaster or metal back splint which is worn for another month but during this time active movements of the knee preferably under the

sudden contraction, and with the knee partly flexed the patella breaks across its middle and the quadriceps expansion is torn across the leg then gives way and as the knee bends the fragments are pulled further apart This is the mechanism of the common transverse fracture of the patella with separation When the patella receives a direct blow the fracture is irregular and if the lines of fracture are radiating is described as stellate there is usually little or no displacement In some cases the aponeurosis of the quadriceps is not torn and there is then little or no separation of the fragments of the patella The patient may then be able to extend his knee and even be able to walk A patient has been known to finish a game of football with a transverse fracture of the patella without separation

Except in the case of fractures of the inferior part of the patella, the knee joint is always involved and a hæmarthrosis results Open fractures of the patella are not as common as might be expected but are of necessity serious because the knee joint is opened

The diagnosis of a fracture of the patella is obvious when there is separation of the fragments because a gap in the bone is easily felt When there is no separation the diagnosis rests mainly on an X ray examination, but care must be taken not to mistake a congenitally separated part of the patella for a fracture (Fig 2) An X ray of the other leg will settle any doubt for this abnormality is usually bilateral.

**Treatment** A fracture of the patella is one for which an open operation is the rule When, however the fracture is stellate or transverse and without displacement no operation is necessary Instead, the leg is immobilised in a plaster of Paris cast which extends from the ankle to the groin and the patient is allowed to walk after the first few days With a large hæmarthrosis it is often best to put a compression bandage firmly round the knee for about a week, in order to get rid of the swelling before putting on the plaster

In the common transverse fracture with separation operation is indicated except in old or feeble subjects There are two main aims of the operation

(1) To remove the flap of aponeurosis of the quadriceps

In those cases where there has been separation of the fragments and conservative treatment is employed fibrous union is likely to result partly because there is a gap between the bones and partly because a flap of aponeurosis lies between the fragments Fibrous union may, if it is close, give as good a functional result as union by bone but there is always a liability for the fibrous tissue to stretch so that the gap gradually increases and may come to be an inch or more this leads to loss of power of extension of the knee In young subjects with bony union in good position a perfect functional result should occur but in those who are older and particularly in those liable to rheumatism some limitation of movement perhaps with pain is likely to occur and definite arthritic changes may supervene

Osteo-arthritis is likely to develop when there is some irregularity in the articular surface of the patella Even by a most careful open reduction it is often impossible to restore a completely regular posterior surface and this is one of the reasons why complete excision of the patella is often preferred to suture

## Dislocations of the Knee

Although the knee joint is very insecurely constructed so far as the bony surfaces are concerned yet a dislocation of the joint is a rarity The cruciate and collateral ligaments as well as the ligamentum patellæ and posterior ligament are exceedingly strong Sprains involving these ligaments particularly the internal lateral, are very common but the united strength of all these ligaments is great and prevents dislocation When force is applied to the knee a fracture is more likely to occur

Treatment Conservative treatment should be tried first The tibia and femur are put in proper alignment and immobilised in plaster for six to eight weeks Movements are then begun and vigorous quadriceps treatment is continued as the strength and stability of the knee depend so much on the condition of this muscle If the knee is then very unstable an arthrodesis of the joint is the only treatment

control of a physiotherapist are allowed and faradism to the quadriceps is carried out This rather long period of immobilisation is advisable because although at the end of one month union might be sufficiently strong to allow simple walking it would not be firm enough to withstand the strain of an unforeseen fall At the end of two months it should be possible to flex the knee almost to a right angle With use the range of movements increases greatly and except in old or arthritic subjects should become full. Some patients continue to complain of pain or weakness in the knee the former is sometimes due to arthritis and both may be due to weakness of the quadriceps This weakness of the quadriceps is a common cause of persistent disability after all injuries to the knee joint and must not be overlooked

In the last few years the operation of excision of the patella in cases of fracture has been practised, having been introduced by Brooke The fragments are exposed by a suitable curved incision and all bone is removed. The aponeurosis and capsule of the joint are then carefully sutured and the limb splinted in a manner similar to that described above The strength of the knee is as good as when the patella has been wired and osteo-arthritis appears to be less likely to occur

The operation has not been practised for a sufficient number of years to enable one to pronounce a final verdict on its merits but it is particularly indicated in open or comminuted fractures of the patella and where there is any osteo-arthritis

In those persons in whom an open operation is contra indicated although there is separation, an effort should be made to approximate the fragments by manipulation A *wooden back splint is applied and the fragments of the* patella held together by several turns of adhesive strapping which are placed obliquely so that some hold the upper fragment down while others draw up the lower fragment The after treatment is the same as when an open operation has been performed but the results are not usually so good

*Results* After operation, provided the fragments have been fixed in close apposition bony union usually occurs

## Chapter XXI

# FRACTURES OF THE TIBIA AND FIBULA

(1) **Fractures of the Upper End of the Tibia**

(*a*) Fractures of the Spine of the Tibia

(*b*) Fractures of the External Condyle

(*c*) Fractures of the Internal Condyle

(*d*) Comminuted Fractures involving the Upper End of the Shaft

(2) **Fractures of the Shaft of the Tibia**

(3) **Fractures of the Fibula**

(4) **Fractures of the Shafts of the Tibia and Fibula**

## (1) Fractures of the Upper End of the Tibia

(*a*) Fractures of the Spine of the Tibia The commonest fracture involving the spine of the tibia is caused by avulsion of a fragment of bone by the anterior cruciate ligament The ligament is attached to a portion of the intercondyloid surface of the upper end of the tibia immediately in front of the spine The fracture therefore consists of a separation of a fragment of tibia immediately anterior to the spine and only involves a small portion of the front of the spine itself A very unusual fracture is separation of the spine itself this occurs possibly as the result of one of the condyles of the femur striking against it

The signs and symptoms of the common fracture of the tibial spine are fairly characteristic the diagnosis is made on the history of an injury to the joint (usually a blow on the lower end of the femur with the knee semi flexed) the presence of a hæmarthrosis and by finding a bony block to full extension An X ray examination confirms the diagnosis

Treatment A general anæsthetic is required and the joint if filled with blood, is aspirated It is then fully and forcibly extended, as this movement is being carried

likely to be effective in reducing disablement Reconstruction of the ligaments with tendon or fascia lata is only temporarily successful

Dislocation of the knee is a very serious injury and a full return of function cannot be anticipated, but the functional result, provided the quadriceps is really strong is often very much better than might be expected

A *dislocation of the patella* is a very troublesome condition Genu valgum predisposes to it and the patella always dislocates laterally so that it lies on the outer side of the lateral condyle of the femur The condition is more common in women and is liable to recur By extending the knee the bone can easily be pushed back into position this is usually done by the patient or her friends If dislocation occurs frequently an operation for re-aligning the patella and ligamentum patellæ must be carried out

corrected, and it is a wise precaution when fixing the leg in plaster to put the knee in a slightly over-corrected position *i e* one of genu varum If there is no displacement the leg is immobilised in a plaster cast in this position

When there is downward displacement or broadening of



FIG 64 Fracture of the external condyle of the tibia. This results from force applied to the outer side of the upper end of the tibia with the foot on the ground. The articular surface of the external condyle is disorganised, the whole condyle being crushed and widened.

the bone a general anæsthetic is given and the tibia is adducted on the femur This movement causes a correction of the downward displacement because the capsule on the outer side of the joint holds the depressed fragment of tibia in close relation to the femur as the rest of the tibia is adducted If an immediate X ray examination shows the

out a bony obstruction will probably be felt, but with some pressure it is overcome, and this actual movement seems to cause the femur to push the separated fragment of the tibia back into position The knee is then fixed in full extension by a plaster cast extending from the groin to immediately above the ankle and after a few days the patient is allowed to get about on crutches but weight bearing should not be allowed for four weeks The cast should be left on for eight weeks after which movements of the knee may be begun but no great strain should be put on the knee at first

If early reduction has not been secured the space between the elevated fragment and the upper end of the tibia becomes filled with callus and *it is usually impossible to reduce* the fracture by forcible manipulation Unless something is done the patient is left with a permanent limitation of extension at the knee In this case it is best to open the joint and expose the fracture Sometimes it will be possible to remove the projecting fragment if it is small and if the attachment of the anterior cruciate ligament can be preserved but when the fragment is a large one it is preferable to remove bone and callus from beneath it so that it becomes possible to replace the fragment by pressure and maintain it in position by full extension at the knee joint

(*b*) Fractures of the External Condyle These are the commonest fractures at the upper end of the tibia involving the knee joint They usually result from a blow on the outer side of the knee and have been christened Bumper fractures because of the frequency with which they occur from impact with a motor car The fracture may take the form of a single large triangular fragment comprising the main mass of the condyle which may be in good position or *be displaced downwards to a greater or less extent In other* cases the separated fragment is severely comminuted compressed and displaced downwards it is also broadened and the articular surface deformed.

**Treatment** Unless the articular surface of the outer condyle is on the same level as that of the inner the patient will have a knock-knee deformity It is therefore essential that any downward displacement is exactly

joint holds the internal condyle in position while the tibia is abducted and thus the displacement is reduced If the condyle is broadened it is compressed with a clamp and the leg then put in plaster with the deformity slightly over corrected so that the leg assumes a position of slight genu valgum The plaster should be kept on for three months after which knee movements are begun and careful walking allowed

(*d*) COMMINUTED FRACTURES INVOLVING THE UPPER END OF THE SHAFT A variety of fractures falls into this group In some cases both condyles of the tibia are fractured and displaced downwards so that a central portion of the shaft surmounted by the intercondyloid surface of the upper end of the tibia projects above them in other cases an irregular transverse comminuted fracture just below the articular surface occurs and the proximal fragment may be displaced either medially or laterally on the shaft sometimes an irregular pulping of the upper end of the bone occurs

**Treatment** These several fractures of the upper end of the tibia are best treated by continuous traction The leg is placed on a Braun s splint with the knee slightly flexed a Steinmann s pin is put through the os calcis, and a weight of about ten pounds is attached. When the shortening has been fully overcome the deformed upper end of the tibia is moulded into shape either by the hands or if necessary by a clamp In difficult cases a method worth trying and suggested by Kindersley of Bath is to surround the upper end of the tibia by an Esmarch s rubber bandage and then, while traction is employed the whole of the upper end of the tibia is hammered on both sides The repeated percussions cause the many small fragments to slip back into position as they are compressed by the elastic bandage The clamp or elastic bandage is then removed and traction is continued for about three weeks after which the leg is immobilised in a plaster of Paris cast. Weight-bearing even in a plaster should not be allowed for three months and after this it is advisable to use a weight bearing caliper for a further three months

Although the immediate results of these severe fractures

position to be satisfactory the leg is then immobilised in plaster

When the outer tuberosity is broadened as well as displaced downwards the tibia is adducted on the femur two pads of felt are placed one on each side of the upper end of the tibia and a clamp used to compress and thus reform the shape of the upper end of the bone the limb is then fixed in a plaster cast extending from the groin to just above the ankle with the knee in a position of slight genu varum It is advisable that no weight should be borne on the leg until the fracture is united firmly The plaster is removed after four to six weeks and the patient begins to regain *movement at the knee but without taking any weight on* the limb At the end of eight to ten weeks a weight relieving caliper is supplied and worn for a further three or four months until bony consolidation of the fracture has occurred.

Occasionally it is not possible to elevate the external condyle into a correct position by manipulation and in such cases a reduction may be obtained by operation If there is a great tendency for the condyle to slide downwards again the loose fragment is fixed in position by a screw

The immediate results of fracture of the outer condyle as regards movement and stability of the knee joint are good when good correction of the displacement has been obtained. But as in all fractures involving the articular surface of joints there is a likelihood of osteo-arthritis in the future and this is almost inevitable in those cases in which a satisfactory correction of the displacement has not been obtained

(c) Fractures of the Internal Condyle These fractures result from accidents similar to those which cause fractures of the external condyle but the injury is on the inner side of the knee so that the tibia is forcibly adducted on the femur Compared with fractures of the external condyle they are a rarity

**Treatment** These fractures are treated on similar lines to a fracture of the external condyle of the tibia, except that in order to reduce the displacement the tibia is abducted on the femur so that the internal lateral ligament of the knee

joint holds the internal condyle in position while the tibia is abducted, and thus the displacement is reduced If the condyle is broadened it is compressed with a clamp and the leg then put in plaster with the deformity slightly over corrected so that the leg assumes a position of slight genu valgum The plaster should be kept on for three months after which knee movements are begun and careful walking allowed

(d) COMMINUTED FRACTURES INVOLVING THE UPPER END OF THE SHAFT A variety of fractures falls into this group In some cases both condyles of the tibia are fractured and displaced downwards so that a central portion of the shaft surmounted by the intercondyloid surface of the upper end of the tibia projects above them in other cases an irregular transverse comminuted fracture just below the articular surface occurs and the proximal fragment may be displaced either medially or laterally on the shaft sometimes an irregular pulping of the upper end of the bone occurs

Treatment These several fractures of the upper end of the tibia are best treated by continuous traction The leg is placed on a Braun s splint with the knee slightly flexed a Steinmann s pin is put through the os calcis and a weight of about ten pounds is attached When the shortening has been fully overcome the deformed upper end of the tibia is moulded into shape either by the hands or, if necessary by a clamp In difficult cases a method worth trying and suggested by Kindersley of Bath is to surround the upper end of the tibia by an Esmarch s rubber bandage and then while traction is employed the whole of the upper end of the tibia is hammered on both sides The repeated per cussions cause the many small fragments to slip back into position as they are compressed by the elastic bandage The clamp or elastic bandage is then removed and traction is continued for about three weeks, after which the leg is immobilised in a plaster of Paris cast Weight bearing even in a plaster should not be allowed for three months and after this it is advisable to use a weight bearing caliper for a further three months

Although the immediate results of these severe fractures

are often surprisingly good especially amongst women and people not employed on heavy work the knee very seldom remains absolutely free from pain and osteo-arthritis supervenes sooner or later The probability of osteo-arthritis developing early is very strong in the comminuted and severely displaced fractures

## (2) Fractures of the Shaft of the Tibia

Fractures of the shaft of the tibia alone without the fibula are so similar in their clinical appearance and treatment to those of both bones together that they will not be described separately and reference should be made to fractures of the tibia and fibula When the fibula remains intact it acts as a splint to the tibia so that there is not usually any shortening With a fracture of the tibia it may rarely occur that union does not take place because the fibula is holding the fragments of the tibia apart It may then be necessary to do an osteotomy of the fibula

## (3) Fractures of the Fibula

Fractures of the fibula alone are usually unimportant except those at the lower end of the bone which are described with fractures of the ankle joint (page 228) A fracture of the neck of the bone often occurs with a fracture of the tibia due to indirect injury A fracture of the head of the fibula very rarely occurs and a fracture of the shaft of the bone which usually results from direct violence is not very common. There is tenderness on local pressure and pain is felt on springing the fibula The common peroneal nerve may be injured as it winds round the neck of the bone other complications are rare

**Treatment** No splint is needed If there is much swelling the patient should be kept off the leg and a moderately firm bandage over wool applied this may be replaced later by elastoplast which gives a feeling of security to the leg If there is not much pain the patient may start walking after the second week. Even if there is displacement of the fracture it is not necessary nor usually possible, to

reduce it Only with a fracture in the lower part of the bone where the external malleolus is displaced is any reduction necessary (see page 234)

### (4) Fractures of the Shaft of the Tibia and Fibula

Fractures of the shaft of the tibia and fibula may result from direct or indirect violence In the former case the fractures are usually transverse or comminuted and the fracture of each bone is generally at approximately the same level In fractures due to indirect violence the fracturing force is often in the nature of a torsional strain, so that the line of fracture is spiral the tibia usually fractures at the junction of the middle and lower thirds of the bone while the fibula gives way in its upper third

Owing to the superficial position of the tibia fractures of this bone are frequently open With a transverse fracture due to direct violence the external fracturing force tears the skin But in the case of oblique fractures the skin is often perforated from within by the sharp lower end of the proximal fragment, and since the skin is perforated by a sterile bone there is not such a danger of infection as when the injury is from without

It is most important to provide adequate preliminary splintage in cases of fracture of the tibia in order to prevent any possibility of injury of the skin by the bone otherwise a closed fracture may be converted into an open one and the responsibility for this will rightly be on the shoulders of the medical man in charge It is uncommon for any nerve to be injured with a fracture of the tibia but the external popliteal nerve as it winds round the upper end of the fibula is occasionally injured

Treatment For the purpose of treatment fractures of the shaft of the tibia and fibula may be divided into four main groups

(1) Those where there is no displacement and in which immobilisation is all that is required

(2) Those in which a proper reduction of the fracture can be maintained by splinting following a simple manipulation.

(3) Those in which continuous traction is necessary
(4) Those in which open reduction and fixation may be advisable

(1) The first group comprises cases in which there are long fissures through one or both bones oblique fractures in the lower half of the tibia without displacement and transverse fractures of both bones with little or no displacement Fractures of the tibia alone usually fall into this group the fibula acting as an adequate internal splint The best external splint for a fractured tibia is a plaster of Paris cast When plaster of Paris is used it must be put on from the toes to the groin and in those cases where there is very great swelling the plaster for the first week should be padded When the swelling goes down this is replaced by an unpadded plaster cast In the case of young children with oblique fractures the plaster should be kept on from six to eight weeks when union will usually be firm enough to allow walking without any splint With adults a long period of immobilisation is required and the presence of bony union must be determined by clinical and X ray examinations Weight-bearing in plaster should not be allowed until union is sound on clinical examination and immobilisation in plaster must be continuous until an X ray confirms the presence of bone across the fracture line When the plaster is removed there may be some stiffness of the knee and the ankle but with exercises full movements will soon return In adults with fractures at the junction of the middle and lower thirds bony union is sometimes very slow in occurring and it may be necessary to leave the plaster on for six months or even longer Nothing is gained by an early removal of the plaster and massage to the limb as union will occur more quickly in a properly fitting plaster cast

(2) In those cases where there is a transverse fracture with angulation as the only deformity and occasionally where there is also an overlapping of the fragments of a transverse fracture it is possible to effect a satisfactory reduction by manipulation If this is the case the treatment after the reduction is the same as that described above

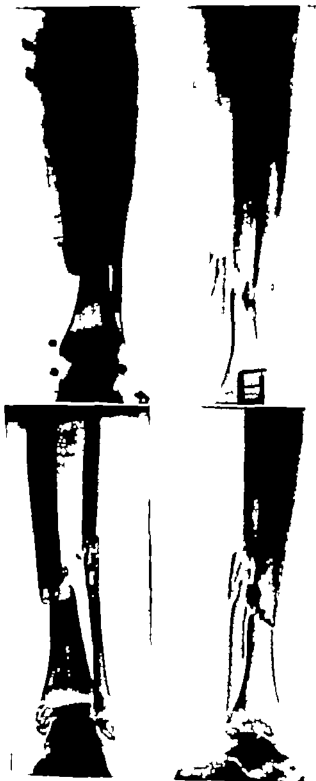


FIG 65 Fractures of the shafts of the tibia and fibula before (*above*) and after (*below*) reduction Both bones show considerable comminution and it is not possible to get all the fragments in perfect apposition; but this is not important, provided the proper length is restored and there is no angulation in any direction. This case was treated on a Braun's splint (page 36) weight being applied by means of a pin through the os calcis.

for cases without displacement Under a general or local anæsthetic any angulation is easily corrected if there is overlapping of the fragments it may be corrected by an assistant making powerful manual traction on the leg for some minutes and then when the shortening has been overcome, the lateral displacement is corrected before the pull is released.

(3) With oblique fractures of the tibia and fibula with most comminuted fractures and with some transverse fractures where there is overlapping reduction cannot be maintained after manipulation unless continuous traction is employed. In such cases the patient is given a general anæsthetic and with full aseptic precautions a Steinmann s pin is inserted through the lower end of the tibia about two inches above the tip of the internal malleolus Traction is then applied either manually or by means of a Böhler or Watson Jones s traction apparatus By traction and manipulation the fracture is reduced During reduction the position can be repeatedly checked by taking skiagrams When a satisfactory position is obtained plaster is applied from the groin to the toes with the Steinmann pin included After a final X ray check the patient is returned to bed but traction is maintained on a Braun s splint (Fig 9) with five or ten pounds weight attached After three to four weeks the traction may be removed as although the fracture is not united by hard callus it is usually united sufficiently by soft callus to prevent shortening of the bone The limb is then taken off the Braun s splint and put in an unpadded plaster cast extend ing from the toes to the groin and the patient encouraged to get about at first on crutches and then by walking on the plaster to which a sponge rubber heel has been added The leg must be kept in plaster until firm bony union is established This is sometimes very long and rarely before four months in severe cases

As already mentioned, delayed union is very common in the lower half of the shaft of the tibia The fibula invariably unites readily

During the whole period of immobilisation of the fracture

in plaster it is most important to maintain the tone and volume of the quadriceps muscle by suitable exercises in plaster Toe movements are encouraged from the start not



FIG 66 An oblique fracture of the tibia treated by open reduction and secured with two screws.

only to maintain the range of movement at the metarcarpo phalangeal joints but also to assist the tone of all the other below knee muscles

(4) Repeated manipulations and heavy or long continued traction are likely to delay the union of a fractured

tibia There are certain fractures of this bone which we know from experience to be unstable and in these the delaying effect of repeated manipulations or traction can be avoided by operation.

Transverse fractures of both bones at the same level are liable to become re-displaced At the first sign of insta bility it is often advisable to expose the fracture of the tibia and after reduction secure the fragments in position with a stainless steel plate and screws Again considerable traction may be required to maintain the position of an oblique fracture in the middle third of the tibia If the fracture is not too oblique it is better to operate and fix the fragments in position with one or two screws placed squarely across the fracture line (Fig 66)

It is necessary to repeat (p 28) that open reduction will fail if there are any imperfections of surgical technique

## CHAPTER XXII

# FRACTURE DISLOCATION OF THE ANKLE

FRACTURES of the tibia and fibula involving the ankle joint are usually associated with the name of Percival Pott who first described them in 1768 It is however, important to distinguish between the varieties of injury at the ankle, and the name of Pott should be associated only with those in which there is a fracture-dislocation with lateral displacement of the foot

It is impossible to discuss the subject properly without making some reference to injuries of the external lateral ligament of the ankle and also to those fractures of the lateral malleolus which occur without dislocation of the ankle

### Injuries of the External Lateral Ligament

The ordinary sprained ankle is caused by a sudden inversion or adduction of the foot The external lateral ligament is overstretched and some of the fibres rupture or become separated from their bony attachments Usually the anterior fasciculus alone is damaged The symptoms and signs are familiar and an X ray shows no bone injury Treatment consists in a short period of rest and support until acute symptoms have subsided followed by exercises to prevent the formation of adhesions and by careful re-education in walking

Sometimes the injury is a more severe one The anterior fasciculus is ruptured the middle fasciculus is grossly overstretched and may be ruptured or torn from its distal attachments If this injury is treated as an ordinary sprain the ligaments will not heal and there will be nothing to prevent the astragalus from tilting inwards and from becoming partly dislocated each time the foot is subjected to inversion and adduction strain This is one of the reasons

for recurrent 'giving way' of the ankle and may be a cause of quite marked disablement The diagnosis of rupture as opposed to mere stretching of the fibular collateral ligament may be suspected from the greater clinical severity of the injury If pain and spasm are not too marked it may be possible to detect the instability of the talus on passive inversion of the foot The actual tilting of the astragalus can be seen on X ray examination, but to carry out this test reliably the patient should be given an anæsthetic and antero-posterior views of the ankles should be taken with each foot forcibly inverted to its fullest extent A tilt of 10 to 15 degrees may be a normal anatomical feature in some individuals Once the diagnosis is established the injury should be treated by the application of a walking plaster which is worn for six weeks With this long period of immobilisation the ruptured ligaments will often heal and the complication of recurrent subluxation will then have been averted.

## Fractures of the Lateral Malleolus

The fibular malleolus is often broken by forcible abduction of the foot or by external rotation of the foot at the ankle The fracture runs obliquely downwards and forwards If the internal malleolus is fractured also or the internal lateral ligament is torn there must have been some dislocation of the ankle although the displacement may be of short duration and may not be present when an X ray is taken. Fracture of the lateral malleolus alone without any dislocation of the ankle is a very common injury but obviously it is important to distinguish those cases in which there has been an additional dislocation or subluxation. An associated fracture of the medial malleolus will, of course be seen in an X ray Rupture of the internal lateral ligament can be detected by the presence of local tenderness, and by the pain which is produced when the injured ligament is stretched by gentle outward pressure against the heel

When there is no evidence that dislocation or subluxation has occurred, fractures of the lower end of the fibula are best treated by a period of four weeks in a walking plaster

## Fracture-dislocation of the Ankle

The classification introduced by Arbuthnot Lane is simple, but does not give a complete picture of the varieties of fracture-dislocation which may occur Ashurst has pointed out the distinguishing features in a more comprehensive manner

There are four sorts of violence which will lead to a fracture-dislocation of the ankle *External rotation* of the foot produces the commonest injury Sometimes the foot is forcibly everted when its inner border strikes against a kerb or step but more often the accident is one of violent inward rotation of the body and leg when the foot is rooted to the ground

*Adduction* or *inversion* of the foot commonly produces nothing more serious than a sprained ankle but occasionally the violence is so considerable that fracture-dislocation occurs

*Abduction* injuries are caused when the outer side of the leg is struck so that the leg is forced inwards and the foot outwards Sometimes the same effect is produced but in the reverse manner when the inner side of the foot strikes against a stair or projection on the ground

A fall on to the foot from a height may produce a fracture dislocation of the ankle of a special type This is the *vertical compression* ' injury described by Ashurst

External rotation adduction or abduction violence produces fractures of both malleoli of differing shape at different levels or else a fracture of one or other malleolus with rupture of the fibular collateral or tibial collateral ligament and in the case of an abduction injury a rupture of the inferior tibio-fibular ligament In any one of these injuries the foot may be dislocated backwards, and a large fragment may be separated from the posterior surface of the tibia including some of its articular surface

Fracture-dislocations of the ' vertical compression ' type are distinguished by two features one the forward dislocation of the foot the other a large triangular shaped fragment which includes the medial malleolus separated from the front of the tibia

FRACTURE DISLOCATION OF THE ANKLE

Injury caused by *external rotation* of the foot at the ankle




FIG 67 *First Degree.* There is an oblique fracture of the lateral malleolus. The gap between medial malleolus and talus suggests that the tibial collateral ligament is torn.



FIG 68. *Second Degree.* Note oblique fracture of lateral malleolus and fracture of medial malleolus at level of joint space.

FRACTURE DISLOCATION OF THE ANKLE

Injury caused by *external rotation* of the foot at the ankle joint



FIG 69



FIG. 70

*Third Degree.* Note that in addition to the fractures of lateral and medial malleolus, there is a fracture of the posterior border of the tibia and that the foot is displaced backwards as well as outwards.

## Fracture Dislocation of the Ankle

Injuries caused by *adduction* or *abduction* of the foot at the ankle



Fig 71. Adduction injury Note the transverse fracture of the lateral malleolus, and the vertical fracture through its base which splits off the medial malleolus.



Fig. 72. Abduction injury Note the fracture of the shaft of the fibula; the fracture of the base of the medial malleolus and the diastasis at the tibio-fibular joint.

FRACTURE DISLOCATION OF THE ANKLE

Injury caused by a fall on to the foot from a height



FIG. 73. FIG. 74

Vertical compression injury. Note from the lateral view that the foot is displaced forwards and from the antero-posterior view that there is a large triangular fragment separated from the front of the tibia, and including the medial malleolus.

## Fracture Dislocation of the Ankle

Injuries caused by *adduction* or *abduction* of the foot at the ankle



Fig. 71 Adduction injury Note the transverse fracture of the lateral malleolus, and the vertical fracture through its base which splits off the medial malleolus.



Fig. 72. Abduction injury Note the fracture of the shaft of the fibula; the fracture of the base of the medial malleolus and the diastasis at the tibio-fibular joint.

FRACTURE DISLOCATION OF THE ANKLE

Injury caused by a fall on to the foot from a height



Fig. 73. Fig. 74.

Vertical compression injury. Note from the lateral view that the foot is displaced forwards and from the antero-posterior view that there is a large triangular fragment separated from the front of the tibia, and including the medial malleolus.

The appearances of the four main types of fracture dislocation can be elucidated from the accompanying illustrations (Figs. 67–74)

Each of these is a fracture-dislocation of the ankle All of them are treated primarily by manipulative reduction by very similar manœuvres In straightforward cases the after treatment of each group is the same Because of these points of similarity it might at first be considered that Ashurst s classification is unnecessarily detailed and exacting There are however certain special complications of the adduction and abduction injuries which make it necessary that they should be recognised and distinguished from the commoner external rotation types In adduction fracture-dislocations the foot is displaced inwards not outwards In both adduc tion and abduction injuries the fracture may run through both malleoli exactly at the level of the ankle joint When this happens it is difficult to keep the talus in its proper position the displacement tends to recur and early walking in plaster is therefore contra indicated Again a flap of periosteum may become interposed between the two frag ments of the tibial malleolus This interposition makes it impossible to reduce the fragments accurately and a distinct gap can be seen in X rays When this occurs it is best to operate and remove the intervening soft tissue so that the fragments may be apposed

Many abduction fracture-dislocations are accompanied by rupture of the inferior tibio-fibular ligament so that when the foot is displaced outwards there is a complete separation or diastasis of the inferior tibio-fibular joint This occurs under two conditions (1) When there is a fracture of the medial malleolus no fracture of the fibula and outward dislocation of the talus and foot (2) When in addition to a fracture of the medial malleolus and outward dislocation of the foot there is a fracture of the fibula above the level of the inferior tibio fibular ligament When diastasis has occurred it is most important to reduce the displacement accurately and to maintain the reduction until the ligament has had time to heal This will take about eight weeks and walking even in plaster is dangerous before this Sometimes

the diastasis leads to instability and recurrent displacement so that operative fixation of the fibula to the tibia becomes necessary

There is no difficulty in recognising the vertical compression type of fracture-dislocation because of the forward displacement of the talus and foot Gross damage to the articular surface of the tibia is a prominent feature and arthrodesis of the joint may be indicated

**Diagnosis** The diagnosis of a fracture dislocation of the ankle is usually obvious but the ugly and sometimes terrifying deformity may soon become masked by great swelling round the ankle The injury is associated with much pain and it is wise as well as kind to correct the displacement as soon as the patient is seen (if it can be done easily) before one undertakes formal reduction This step gives considerable relief from pain.

Compound injuries are not common but the lower end of the tibia from which the medial malleolus has been separated may project through the skin

X ray examination will confirm the diagnosis anyhow as far as the fractures of the tibia and fibula are concerned but it is as well to remember that a considerable displacement of the ankle joint may have been reduced as a first aid measure so that the radiograms may not convey a complete idea of the amount of damage to the ankle joint itself

Scrutiny of the X ray films will show which of the four types of fracture-dislocation has occurred.

**Treatment** Reduction must be carried out at the earliest possible moment The presence of swelling or fracture blisters should not deter one from proceeding immediately as each day of delay makes perfect reduction more difficult After reduction the patient should be kept in bed for some days and should be under careful observation. It is therefore inadvisable to treat individuals with these injuries as out-patients for the first ten to fourteen days

The patient is given a general anaesthetic To reduce the dislocation the knee must be flexed and this is done by having the patient s leg hanging over the end of a high table while the surgeon sits on a low stool and supports the toes of

the affected limb on his knee Provided there is proper relaxation of the muscles reduction is not usually difficult Backward or forward displacement is corrected first then abduction or adduction and finally the malleoli are pressed firmly back into place against the lateral and medial walls of the talus. There is sometimes a tendency to invert the whole foot but any inversion or eversion must be guarded against and the foot put up in neutral position and at 90 degrees at the ankle The leg is put in plaster from the heads of the metatarsals to just below the knee with the dorsum of the foot and bony prominences protected by padding Antero-posterior and lateral X rays are taken, while the patient is still under anaesthetic on the table If the position is not satisfactory the plaster is removed and the ankle manipulated again Once a good reduction has been obtained the patient is returned to bed and the leg elevated on pillows or on a Braun s splint It is not necessary to split the plaster as a routine provided the patient can be kept under constant skilled observation. If severe swelling occurs and the circulation in the limb begins to be obstructed the cast should immediately be divided down each side If the plaster is bi valved by cutting it down front and back proper control of the fracture is lost

At the end of a week or ten days the plaster is usually found to be loose and should be changed It is advisable to take an X ray before changing the plaster so that if it is found then that some displacement has recurred, arrangements may be made to correct the displacement under an anaesthetic and to put on a fresh plaster Whatever happens an X ray must be taken after the new plaster has been applied

The patient will have been taught to exercise knee and toes from the first and he is now allowed to get up on crutches. Six weeks after the injury a walking heel is added or a new plaster is applied and he is taught to walk correctly in plaster

After ten weeks the cast is removed and clinical and X ray tests will show whether the fractures of the malleoli are sufficiently united for the plaster to be discarded altogether

When the plaster is finally removed it is a good practice to put the patient back to bed for two or three days until he has regained some control of the muscles acting on the ankle and foot and some movement at these joints An elasto plast bandage is then applied and he is taught to walk with the aid of two sticks and wearing ordinary shoes or boots rather than bedroom slippers The limping which occurs with early walking is often due more to weakness of the calf muscles than to stiffness of the joints Exercises to increase the power of the calf and other muscles are just as important as those which aim at restoring movement to the ankle and tarsus

Some fracture-dislocations of the ankle are remarkably unstable after reduction and displacement may recur when ever the plaster becomes loose whenever it is changed and when the patient first begins to walk in plaster It is most important to remember this and to arrange for X rays at regular intervals and always after any change of plaster

*Mal union* If a fracture-dislocation is seen some time after the injury and is in bad position there are three possible lines of treatment

(1) A closed manipulation
(2) Open reconstruction of the joint
(3) Arthrodesis of the ankle

In the first few weeks a closed manipulation may be successful in unreduced cases It is not usually possible after more than six or seven weeks

In general reconstruction operations do not give satisfactory results The articular surfaces have become so distorted that when put back into their correct position they do not fit properly

In these late cases if closed manipulation has failed and reconstruction is considered inadvisable there are two courses open—either to leave the patient alone making him as comfortable as possible with a well fitting supporting boot or to do an arthrodesis In those cases where there is persistent pain and clinical evidence of arthritis the latter operation will give the patient comfort and satisfaction.

The results of fixing an ankle joint are good, provided it is in neutral position as regards eversion and inversion. The loss of mobility at the ankle is compensated for by increased movement at the mid tarsal joint and a patient may be able to do heavy work with a fixed ankle provided this does not involve climbing ladders or walking on uneven ground.

## CHAPTER XXIII

# FRACTURES OF THE TARSUS

### Fractures of the Os Calcis

FRACTURES of the os calcis are likely to be so disabling that they will be described at some length They are much commoner in men than in women and are usually caused by a fall from a height on to the heels A fall of even a few feet may produce the fracture



FIG 75 Skiagram showing a normal os calcis. The internal architecture is well seen and uninterrupted The upper surface of the bone is divided into two parts which meet at an angle of about 30 degrees.

They are not infrequently bilateral and may very often be associated with a compression fracture of the spine or with a head injury and cerebral concussion This particular association of multiple injuries is of considerable significance because often one of the lesions may be completely overlooked in the presence of the other

**Diagnosis** A fracture of the os calcis should always be suspected when the patient after falling from a height has pain in the heel Pain and tenderness on the under surface of the heel though often present are not so characteristic of fracture as tenderness at the side of the bone when the heel is compressed between the fingers Broadening of the heel often occurs and is a most characteristic sign of fracture The final diagnosis depends upon X ray examination. In addition to a true lateral view an axial view at right angles to it must be taken. This view may be obtained by pressing the foot down with the film under the heel, the ankle being dorsiflexed the X ray tube is placed above and behind the heel and at an angle of 45 degrees to the film In the view obtained the posterior projecting part of the os calcis stands out clearly from the surrounding bones. In good pictures the sustentaculum tali and the calcaneo-cuboid joint can be seen clearly



FIG 76 The normal tuberosity joint angle formed between two lines, one from the highest point to the anterior angle and the other from the highest point to the upper part of the tuberosity is shown (*Lancet*)

It is not always easy to recognise displacement in the lateral view unless careful attention be paid to the tuberosity joint angle (see Fig 76 and Fig 78) An ordinary antero-posterior view of the ankle joint should also be taken to exclude other injuries but is of no value in the diagnosis of fractures of the os calcis

## Types of Fracture

A variety of fractures of this bone occurs A great many have been described and the nomenclature is confusing As regards treatment and prognosis they can be divided into three main groups*

* Watson-Jones. Fractures and Joint Injuries," Vol. II

(1) Isolated fractures of processes'
(2) Crush fractures of the body without severe damage to joints
(3) Crush fractures of the body with severe damage to articular surfaces

(1) *Isolated Fractures of Processes'* These include the so-called beak fractures in which a triangular fragment is split off and elevated from the ' dorsal area just



FIG. 7 Fracture of the medial tuberosity of the os calcis. View of the os calcis seen here is the postero-superior oblique view and shows up very well the posterior half of the bone as seen from above and behind. Certain fractures can only be recognised when this view is obtained and it is only in this view that the amount of widening of the os calcis following a fracture can be appreciated

in front of and above the attachment of the Achilles tendon The mechanism of this injury is obscure It is possibly due to direct violence but is certainly not a traction fracture because the integrity of the calf muscle is unaffected The fragment can sometimes be replaced by direct manipulation and after a few weeks rest in plaster there is seldom any interference with function. If reduction has failed and the

displaced fragment gives rise to painful symptoms it can be removed by operation.

The medial surface of the posterior end of the os calcis or the sustentaculum tali may be split off by direct violence Here again reduction can often be effected by direct pressure and significant after-effects are unusual

There is occasionally an oblique fracture which separates a small fragment from the anterior end of the calcaneum. The fracture runs into the articular surface of the calcaneo-cuboid joint The fracture is very often missed in examining X rays but if the injury is not treated by an adequate period of rest a painful traumatic arthritis of the calcaneo-cuboid joint may supervene



Fig 78 Fracture of os calcis showing compression with flattening as indicated by complete loss of tuberosity joint angle " so that all three points are in a straight line (cf Fig 6) The heel is very short. (*Lancet.*)

(2) and (3) *Crush Fractures of the Body of the Os Calcis* These are the classical fractures of the heel and may or may not be associated with destruction of articular cartilage and displacement in the sub-astragaloid and mid tarsal joints

The principal features of the damage to the bone are indicated in Fig 78 The fracture is comminuted a large central fragment including the major part of the upper articular surface is forced downwards into the body of the calcaneum The angle normally formed by the posterior and anterior halves of the body and represented by the tuberosity joint angle is decreased and may be obliterated This angle by lever action assists the calf muscles to exert their maximum power through the Tendo Achillis When the angle is lost the tendon becomes relatively too long and the power of the calf muscle is considerably diminished. Comminution may extend and usually does into the sub-astragaloid and calcaneo-cuboid joints in addition the upward displacement of the anterior part of the os calcis results in subluxation at the calcaneo-cuboid

joint The heel is spread out laterally and medially and there may be spurs of bone projecting under the skin at the side or under surface of the heel

Compound fractures of the os calcis very easily become infected the infection is difficult to overcome and there



FIG 79 Fracture of the os calcis. A crush fracture of the os calcis in which the whole bone is flattened and the sub-astragaloid joint disorganised Compare the upper surface of this bone with that in Fig 75 especially with regard to the angle at which the two parts of the upper surface meet

may be danger to the limb but closed fractures are no less potentially disabling in their effects

The main reasons for disablement are —

Projecting spurs of bone
Widening of the heel
Relative lengthening of the Achilles tendon causing weakness of the calf muscles
Tarsal arthritis.

*Projecting spurs of bone* may cause pressure against the shoe or the ground, which is painful. It is often feasible to operate and remove the spurs or pressure can be relieved by suitable padding

*Broadening of the heel* makes it difficult for the patient to wear ordinary shoes and a surgical boot or shoe may be required.

For the mechanical reason which has been described there may be considerable *weakness of the muscles of the calf* This weakness produces a limping gait and the leg becomes easily tired. Climbing ladders may be quite impossible and the patient finds it difficult to get up or down stairs Resulting as it does, from loss of the tuberosity joint angle this weakness of the calf muscle is often regarded as a reason for making efforts to restore the shape of the os calcis after a compression fracture The methods which are used involve skeletal traction of one sort or another The results are uncertain enough to make it doubtful whether such strenuous manipulations are worth while In spite of some relative lengthening of the Tendo Achillis, weakness of the calf can be largely overcome by really careful and persistent attention to exercises beginning soon after the injury

*Traumatic arthritis* and later osteo-arthritis of the sub-astragaloid and mid tarsal joints is the most frequent cause of severe disablement From the practical point of view it is true to say that once sub-astragaloid arthritis has developed it is completely resistant to any form of treatment It is therefore important to try to prevent the onset of arthritis

In the early stages of the injury treatment is directed not towards restoring mobility but to preserving the damaged joints from over irritation by movement and pressure Exercises are performed to regain movement at the ankle and toe joints and to restore the power of the calf muscles. Exercises for inversion and eversion which take place at the sub astragaloid and mid tarsal joints are prohibited neither is the patient allowed to take weight on the foot for at least eight weeks after the injury In

those fractures in which damage to the joints has not been severe movement will return automatically with active use in the later stages of treatment but arthritis will have been avoided. When there has been severe comminution spontaneous fusion may take place With bony ankylosis, or even with a firm fibrous ankylosis, perfect function can be regained

The symptoms and consequent disablement from an arthritis of the sub astragaloid and mid tarsal joints may diminish with time and if the individual is able and prepared to modify his activities Symptoms may be relieved by the support provided by a short outside steel ' with T-strap to the inner side of the heel of the boot In many cases pain and disablement justifies a deliberate operative fusion of the sub astragaloid and mid tarsal joints

**Treatment** *Isolated Fractures of Processes* When describing these injuries reference was made to their treatment It is often possible to replace the fragments by manipulation but if this fails it may sometimes be necessary to remove a projecting fragment Occasionally an apparently minor fracture which involves the calcaneo cuboid joint may give rise to such a painful and disabling arthritis that fusion of the joint becomes necessary On the whole these less important fractures of the os calcis do well after four weeks rest in a walking plaster

*Crush Fractures of the Body without Severe Damage to Joints* These injuries are very painful in the early stages and it is best to immobilise and rest the ankle and foot in a lightly padded plaster extending from just below the knee to the metatarsal heads The patient can be up on crutches but to prevent swelling short periods of activity should be alternated by rest with the limb elevated Exercises for the knee and toes are carried out from the first

After two weeks the plaster is removed and the foot and leg covered with a supporting bandage of crêpe or elastoplast For the next six weeks no weight should be taken on the limb It is important during this stage to regain movement and power at the ankle and toe joints but no efforts are made to mobilise the tarsal joints

Eight weeks after the injury a walking plaster is put on and the patient is taught to walk at first with the aid of two sticks and later without This walking plaster is removed after a month and ordinary walking begins

*Crush Fractures of the Body with Severe Damage to Articular Surfaces* Many elaborate and mechanical means of restoring the shape of the os calois and re-aligning the joint surfaces have been described and advocated. On the whole present day opinion holds that the game is not worth the candle because sufficient correction of displacement cannot be obtained by these methods to obviate the risk of tarsal arthritis.

From this viewpoint the more severe fractures should be treated in precisely the same manner as the preceding group in which deformity and damage to the articular surfaces are not pronounced. However in this more severe group the liability to arthritis is marked and unless firm ankylosis of the sub astragaloid joint occurs disablement will be considerable Sometimes the comminution is so gross that bony ankylosis is inevitable and in this case rather paradoxically the results are consequently good

In those cases in either group in which a painful tarsal arthritis has developed, operative fusion of the sub-astragaloid calcaneo-cuboid and talo-navicular joints is often necessary With experience in the treatment of fractures of the os calcis it is often possible to pick out cases in which arthritis is inevitable and to cut short a long period of disablement by an arthrodesis carried out about a month or six weeks after the injury

## Fractures of the Astragalus

*Chip and Flake Fractures* The majority of simple fractures of the astragalus are avulsions of small flakes of bone from the medial and lateral surfaces and are really variations of sprains of the ankle They clear up rapidly with a short period of immobilisation in a walking plaster followed by re-educational exercises

Sometimes the posterior tuberosity of the astragalus may be developed as a separate ossicle and is known as the os

trigonum The latter must not be confused with a fracture of the tuberosity and although their differentiation may sometimes be difficult in the case of an ossicle, an X ray will show a continuous line around it

*Fractures of the Neck of the Astragalus* Are easily recognised in an X ray, but must be carefully distinguished from those fractures in which there is also a dislocation or subluxation of the sub-astragaloid joint Simple fractures of the neck are seldom displaced and are treated by immobilisation in a walking plaster for six to eight weeks

*Fracture-dislocations of the Astragalus* There are two varieties of fracture-dislocation of the astragalus, in one there is a fracture through the neck of the bone with subluxation or actual dislocation of the tarsus at the sub astragaloid joint in the other the bone is fractured through the neck but the body of the astragalus is dislocated backwards out of the ankle and sub-astragaloid joints Fractures of the neck and both types of fracture-dislocation of the astragalus are caused by a force directed against the sole of the foot just in front of the sub astragaloid joint and producing dorsiflexion of the ankle The forcible dorsiflexion fractures the neck of the astragalus against the anterior margin of the tibia and being continued dislocates the sub astragaloid joint and the body of the astragalus

This sort of blow is an unusual one in the ordinary accidents of civilian life because falls from a height on to the heels produce fracture of the os calcis but is quite common in aircraft crashes and sometimes occurs in motor-cycle accidents.

*Fractures of Neck of the Astragalus with Sub-astragaloid Dislocation* The fracture line runs almost vertically through the neck of the astragalus and on first examination of the X ray may seem to be the only injury but careful scrutiny will show that the os calcis is displaced forwards and the subastragaloid joint dislocated The displacement of the head of the astragalus is upwards so that reduction is secured by full plantar flexion of the foot and it will be found that this will restore the alignment of the sub astragaloid joint The foot is immobilised in plaster in the

plantar flexed position for a month, the plaster is then changed and further immobilisation till the fracture is united is continued with the foot at a right angle at the ankle joint

It is of great importance to distinguish this type of fracture-dislocation from the simple fracture of the neck of the astragalus If the alignment of the sub-astragaloid joint is not restored to normal, a painful disability of the foot will always result

*Fractures of the Neck with Dislocation of the Body of the Astragalus* The body of the astragalus is completely dislocated backwards out of the ankle joint and rotated so that the fractured anterior surface is facing outwards This is a rare injury but the treatment presents three features of importance First the fracture-dislocation must be treated as a surgical emergency otherwise the skin over the body of the astragalus will slough and a septic arthritis of the ankle and sub-astragaloid joints will result Secondly reduction can only be secured after the ankle joint has been opened up by traction through the heel by means of a Steinmann s pin. Lastly the body of the astragalus should be preserved if possible as the results of astragalectomy for this condition are not satisfactory

*Total Dislocation of the Astragalus* Dislocation of the whole astragalus completely out of the ankle sub-astragaloid and astragalo-scaphoid joints sometimes occurs but it is very rare and unusual. Very often the injury is compound and the astragalus has been torn out of the wound and lost In closed injuries open reduction is usually necessary and must be regarded as urgent otherwise sloughing of the skin will occur

## Fractures of other Bones of the Tarsus

Fractures of the scaphoid, cuboid or any of the cuneiforms may occur The injury is usually in the nature of a crushing of the foot although sometimes a linear crack may occur in the scaphoid from indirect injury by sudden inversion of the foot Except for this most of the other fractures of the tarsus are variable and irregular, frequently comminuted and in most cases involving the joints of the tarsus One

rather characteristic fracture consists of a compression of the outer half of the scaphoid with medial displacement of the inner half of the bone in relation to the head of the astragalus and perhaps combined with fractures of the surrounding tarsal bones Occasionally sprain fractures occur small flakes of bone being dragged off by ligaments, usually on the dorsum of the foot

**Treatment** When there is no displacement the foot should be immobilised in a plaster cast with the ankle at a right angle and the foot midway between inversion and eversion and the longitudinal and transverse arches supported by moulding the plaster this is kept on for from six to eight weeks depending on the age and weight of the patient but if the plaster is supporting the foot well the patient may be allowed to walk with the addition of a heel

When there is displacement with fractures of any of the bones combined with dislocation causing deformity of the foot the shape of the latter must be reconstructed by manipulation and the whole immobilised in plaster in the best position Even in bad fractures of the tarsus an open operation is rarely indicated

From the X ray appearance it may be tempting to do an open operation and set the bones in position yet usually little more can be done when the pieces are under vision than by manipulation The use of a wedge or wrench may be necessary when the foot is badly deformed A functionally useful foot should follow if a good general shape can be obtained but there will be little or no movements at the tarsal joints though ankle movements will be normal

## Chapter XXIV

# FRACTURES OF THE METATARSALS AND PHALANGES OF THE FOOT

## Fractures of the Metatarsals

Fractures of the metatarsals most commonly occur as the result of crush accidents although sometimes they result from indirect violence One or more metatarsals may be fractured and when due to direct violence it is usual to



Fig 80 "March fracture of the fourth metatarsal with recent callus formation. There is an old fracture of the second metatarsal.

find several of them fractured transversely at approximately the same level In this type of case there may be lateral displacement with overlapping though more often there is no displacement, or at least none which requires correction

Two special fractures of the metatarsals must be referred to

(1) March fractures
(2) Fracture at the base of the fifth metatarsal (Jones)

A march' fracture is seen typically in either the second or third metatarsal it occurs spontaneously in soldiers postmen and others who do much walking, is situated a little distal to the mid point of the bone is transverse and without much displacement The patient complains of pain in the foot accompanied by local tenderness which is followed by swelling most marked on the dorsum It is not necessary here to go into the details of the abnormalities of structure of the foot which accompany and are believed to predispose to this fracture

A transverse fracture of the base of the fifth metatarsal separating the styloid process but without much displacement occurs as the result of indirect violence The history is usually that of a sudden inversion of the foot and it is believed that the styloid process is separated by the pull of ligaments or tendons—perhaps by the peroneus brevis



FIG 81 Fracture of the base of the fifth metatarsal This is a classical fracture and follows a sudden inversion of the foot. The base of the bone is probably pulled off by the peroneus brevis tendon which is attached to it. This fracture is not to be confused with the accessory ossicle—os Vesalii—which is sometimes present in this position.

Treatment Fractures of the metatarsals in which

there is no displacement requiring reduction may be immobilised either by adhesive strapping or plaster of Paris When one or two of the inner metatarsals—i e second, third and fourth—are fractured, it is sufficient to support the whole metatarsus by a number of turns of strapping around it The same treatment may be used for a ' march fracture or that at the base of the fifth metatarsal when there is no displacement However unless pain is completely relieved by strapping and the patient able to walk in comfort it is far better to apply a walking plaster The toes should be kept off the ground so a Böhler iron is used but active movements of the toes must be encouraged The plaster can usually be discarded in four weeks

When there is displacement an attempt must be made to correct it by manipulation if this is successful the foot should be put in plaster as already described. It is most important to see that no angulation convex towards the sole is allowed to remain If reduction is not obtained by manipulation it will be necessary to employ some method of continuous traction. Many methods have been devised, but one of the simplest is to put the foot in a plaster cast which reaches above the knee but ends below about the level of the necks of the metatarsals A piece of stout wire is incorporated in the plaster at each side so that it extends round the front of the toes about two inches distal to them traction can now be obtained on the toes by fixing a finger of a cotton glove on to them by mastisol durofix or glue A tape or strong rubber band is then stitched to the *end of the glove finger and tied to the wire frame* by adjusting the strength and direction of the pull it is possible to obtain and maintain a satisfactory position of the fracture After two to three weeks this may be removed and the foot put in a complete plaster cast In these cases the plaster should be kept on for six weeks

After some fractures of the metatarsals the foot remains stiff and painful for some weeks Exercises and walking in a comfortable shoe with if necessary the addition of a sponge rubber insole is the best treatment for improving the function.

## Fractures of the Phalanges of the Toes

The commonest fracture of the toes is a crush fracture of the distal phalanx of the great toe From "run-over" accidents several toes may be fractured with or without displacement and may be combined with dislocations at the inter phalangeal or metatarso phalangeal joints

For a fracture of the middle or distal phalanges of one of the toes any metal wooden or plaster splint is unnecessarily cumbersome The toe should be surrounded with several turns of adhesive strapping which will form an adequate support for the fragments and at the same time allow the patient to walk In the case of the fourth and fifth toes even strapping is often unnecessary and may add to the discomfort For the proximal phalanges of any of the toes except the great toe strapping is suitable and efficient For the great toe more adequate immobilisation is required, and the whole foot should be put in plaster with an extension forward under the toes supporting them firmly and protecting them from movement Any hæmatoma under the nail of the hallux should be evacuated as soon as possible this step alone will produce great relief in this painful disability

When there is displacement of any of the phalanges it may be possible to manipulate the fragments into position and to hold them there by strapping the toes If redisplacement tends to occur in the case of the big toe in which any deformity is a real disability a Böhler s unpadded wire finger splint attached to the foot by plaster of Paris should be used The whole foot is put in plaster and the wire splint fixed to the dorsum so that it projects out beyond the end of the toe The toe is secured to the end of the splint as described for fractures of the phalanges of the fingers (see page 160) and continuous traction maintained This may be removed at the end of three weeks and the toe strapped for a further week

## Chapter XXV

# FRACTURES AND DISLOCATIONS OF THE SPINE

Fractures and dislocations may occur separately in the spinal column or they may be combined as fracture-dislocations In a fracture of the skull the injury to the brain is the only thing that really matters the fracture of the bone being relatively unimportant In the case of the spine while the injury to the spinal cord is of greater importance than the bony lesion as regards prognosis and life the fracture of the bone is also of great importance because it has to bear a large part of the weight of the body It is only in the cervical region that a dislocation is seen without fracture Fractures of the body of a vertebra or of some part of the neural arch may occur without dislocation in any region of the spine and fracture-dislocations are also seen throughout the column

The following injuries of the spine will be discussed

**Fractures of the Neural Arch**
- Transverse processes
- Laminæ
- Spinous processes

**Injuries in the Dorsal and Lumbar regions**
- Compression fractures of the vertebral body
- Fracture-dislocation.

**Injuries in the Cervical region**
- Compression Fractures of the Vertebral Body
- Dislocation and Subluxation.
- Fracture-dislocation

**Dislocation and Fracture Dislocation—with Injury to the Spinal Cord**

### Fractures of the Neural Arch

Fractures of the *transverse processes* are most commonly seen in the lumbar region A developmental failure of fusion

of one or both transverse processes of the first lumbar vertebra is a common condition is often bi lateral, and must not be confused with a fracture It is less commonly seen in the lower lumbar vertebræ The smoothness of its surface and the presence of a continuous layer of cortical bone will indicate a congenital separation as opposed to a fracture Fractures of the transverse processes may occur from a direct injury or from the violent pull of muscles In either case it is common to find the processes of several vertebræ fractured and there is usually a considerable degree of bleeding sometimes forming a large retroperitoneal hæma toma There is no question of reducing or replacing the fractured transverse process and treatment consists of rest in bed for about ten days followed by a course of graduated spinal exercises For most patients a broken back ' is of frightening significance and the difference between a com pression fracture and a fracture of the transverse process or spinous process must be explained to them as soon as possible and confidence restored Without this explanation the result in a fracture of the transverse processes may be worse than that following a compression fracture

Fractures of the *laminæ and spinous processes* usually result from direct violence and are most often seen in the cervical and upper dorsal regions If there is no displace ment no special treatment is required other than rest and physiotherapy If a lamina is displaced so as to cause compression an open operation is necessary

## Injuries in the Dorsal and Lumbar Region

### Compression Fractures of the Vertebral Bodies

This injury appears to occur more frequently than in years gone by but it is probable that its actual occurrence is not more frequent but that its clinical and radiographic recogni tion have so improved that cases are not now so frequently overlooked It may occur in a variety of ways and some times from a comparatively trivial injury A doubling up accident as when something collapses on a man s head and shoulders is a common way as also is a fall sometimes

from but a small distance on to the buttocks With the latter injury the suddenness of the fall rather than its severity causes the whole weight of the upper half of the body to be thrown forwards, putting a great strain on the bodies of the vertebræ in the lumbo-dorsal region The articular facets are strong and do not fracture nor become displaced and thus as the body of the vertebra collapses it becomes wedge-shaped because the facets prevent compression of the posterior part Compression may be considerable so that an obvious kyphosis is present but more often this is not immediately seen as the compression is only slight and this combined with the fact that the symptoms are sometimes relatively insignificant is the reason why a number of these fractures are at first overlooked. If they are not recognised and the patient goes about without any support the vertebral body collapses further and a well marked angular deformity appears The cases described as examples of Kümmell s disease many of which have been reported are almost certainly overlooked compression fractures of the bodies of the vertebræ and are not due to any obscure post-traumatic pathological change in the bone The descriptions and case records of Kümmell s disease have however been of con siderable service for they have drawn attention to the frequency of compression fractures of the vertebræ and the comparative mildness of the early symptoms and signs in many of the cases

In all instances where a patient complains of pain in the back following an injury which may have only indirectly affected the spine X rays should be taken An antero-posterior view is of little value in showing a compression fracture of the body and if cases of slight compression are to be recognised a good lateral view must always be obtained In stout persons it is not always easy to get a good one and if after repeating the X rays there is any doubt about the diagnosis it is better to treat the patient as though he had a compression fracture particularly if there is pain aggra vated by standing up It is possible that by the time the patient is first seen a compression fracture of a vertebral body has at least to some extent opened out as a result of

his lying down and an X ray taken in this position may fail to show the fracture If the patient is then sat up and further views are taken the fracture will almost certainly be revealed

It is in the lower dorsal and upper lumbar regions, particularly in the last two dorsal and the first two lumbar vertebræ that a compression fracture most commonly occurs The diagnosis of such a fracture usually depends on X rays but with the history of a typical accident and the presence of localised pain and a kyphosis in the lumbo-dorsal region a diagnosis may be made with confidence As there is no displacement other than collapse of the vertebral body, the cord will not be compressed and grave symptoms are but rarely seen When present they are probably due to spinal shock, and usually disappear after a short period

Treatment With early recognition of the condition and proper treatment, a perfect result can be obtained and the patient will return to heavy manual work. With neglect of treatment permanent deformity and continuous severe pain in the back are likely to result

A word must be said about the transport of a patient with suspected fracture of the spine The movement which will do most damage to the spinal cord is flexion of the vertebral column. On no account, therefore, must the recumbent patient be seized by the shoulders and legs, as this sharply flexes the spine It is recommended that the patient should be lifted and carried in the prone position, as thus will keep the spine hyperextended. If because of other injuries or the concussions of the accident he has to be lifted in the supine position every effort must be made to keep the spine at least straight and preferably hyperextended

As soon as the patient is sufficiently recovered from shock and provided there are no symptoms of cord injury a plaster of Paris jacket should be put on with the spine in the hyperextended position The method described by Watson Jones is the most effective and easy An anæsthetic is not necessary but a dose of omnopon gr $\frac{1}{3}$ or morphia, gr $\frac{1}{4}$ together with scopolamine, gr $\frac{1}{150}$, should be given one

hour previously A general anæsthetic may be given but it adds considerably to the difficulties of the procedure The patient lies prone on two tables the legs rest on a lower table and the head and shoulders on the other which is about one and a half feet higher depending upon the size of the patient By this means the chest and abdomen are unsupported and the weight of the body causes the spinal column to assume an extended position If the patient is left unsupported in this position for some minutes the spine gradually hyperextends and the compressed vertebral body opens out and assumes a more normal shape The trunk is covered either with a double layer of stockinet or a vest which should fit closely without wrinkles A plaster jacket is then put on by surrounding the body with plaster of Paris bandages, which should reach below to the symphysis pubis and above to the sterno-clavicular joints It must be moulded so as to fit snugly over the anterior superior spines and iliac crests which should be padded, and above it should be cut out so as not to press in the axillæ It is made to fit well into the lumbar curve and here also a little padding is advisable The jacket thus maintains the patient in a hyperextended position by keeping the lumbo-dorsal region forwards and the upper part of the chest backwards its weight being supported below on the iliac crests A satisfactory reduction of fractures in the lumbar and lumbo-dorsal region is usually obtained by this method. Fractures in the middle and upper dorsal region are more difficult to reduce and some degree of permanent deformity must often be accepted Luckily however a kyphus in the dorsal region does not produce the degree of disablement which would result from a similar deformity in the lumbar region



FIG 82 Position of body supported on two tables for the application of a plaster jacket in the case of a fracture of the body of a vertebra. The pelvis being unsupported tilts forward and the spine assumes the full degree of hyperextension as the body sags. (From article by Watson Jones. *Journal of Bone and Joint Surgery* )

After the first few days patients usually find the plaster jacket reasonably comfortable, and trouble with pressure sores is uncommon except over the spines in the lower dorsal region To prevent this Watson Jones has suggested the use of a pad of adhesive felt six inches by four which covers the spines in this region, a window in the plaster over the felt is cut but it must be smaller than the latter (about four by two inches) and the felt must not be cut

Although a plaster jacket will support a patient adequately and make him comfortable wasting of the erector spinæ muscles will occur, and the importance of exercises for these muscles throughout the whole period that the plaster is worn cannot be too strongly emphasised As soon as the plaster jacket is dry and firm the patient must be taught a series of simple exercises and encouraged to carry them out at regular intervals throughout the day The main exercise consists in active extension of the trunk with the legs supported and until he can lift his trunk in plaster in this way with confidence the patient should not be allowed to get up Once he is getting up the exercises should be increased in severity until he can play games carry weights on his head or even return to work in plaster

No fixed time can be given for removal of the jacket but in average cases the spine will be in plaster for three to four months With older or heavier patients and those with weak muscles or in whom the bone is badly comminuted, a longer period may be necessary The decision as to when plaster can be discarded will depend on the appearance of consolidation of the fractured vertebra as seen in an X ray

As regards results similar cases although similarly treated, do not always get equally good results but provided a good reduction is obtained and the spine is immobilised for a sufficient length of time and the muscles are not allowed to waste a painless back sufficiently strong for heavy work should be obtained in the majority of cases in six to eight months If a patient with a fractured spine is fortunate enough to have a light occupation he may with advantage return to it wearing a plaster

In a few patients pain at the site of fracture continues for

many months and in such cases the advisability of doing a bone graft to fix the spine must be considered, although this will limit to some extent the mobility of the spinal column, this disadvantage will however be outweighed by the relief from pain the operation confers Those fractures in which there has been considerable comminution of the body of a vertebra as well as compression and wedging are most likely to give rise to persistent backache It is in these cases that operative fusion of the spine is particularly indicated.

### Fracture-dislocation

A fracture-dislocation is a further degree of compression fracture The displacement is usually that of the upper vertebræ forward on the lower For this to occur either the ligaments between the neural arches must be torn, or the arch fractured, and except in the cervical region, the articular facets are also usually fractured Such a fracture-dislocation is combined with a compression fracture of the body of the lower vertebra There may sometimes be quite a *surprising amount of displacement of one vertebra on the* other without the cord showing signs of injury and this is especially so in the lumbar region where the spinal cord has given place to the cauda equina In the dorsal region the cord almost fills the spinal canal, and damage is likely to be caused by even a slight displacement of the vertebræ It is most important to recognise when compression fracture of a vertebral body is complicated by dislocation of the vertebræ and this may not always be as easy as it would seem When the neural arch is broken and there is gross displacement the condition will be obvious and there is usually evidence of paraplegia In other cases because of the fracture of the neural arch the vertebral column is very unstable and careless handling of the patient will soon produce forward displacement and damage to the spinal cord There is a third group in which a severe flexion injury produces a compression fracture and tears the ligaments between the neural arches *the upper vertebra slips forwards* a little and then some slight twisting of the upper part of the

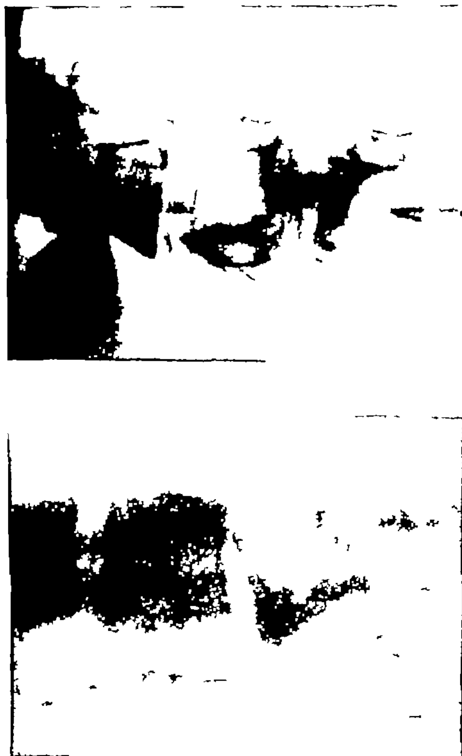


Fig 83. Fracture-dislocation of the spine. The upper vertebra (Dorsal 12) is displaced forwards and outwards on the lower (Lumbar 1). The articular processes are locked

trunk during the accident rotates the articular processes of the upper vertebra so that one of them comes to lie in front of the articular processes of the lower vertebra. The articular processes on one side become impacted or "locked" in this position. Once this displacement and impaction have occurred any attempt to reduce the compression fracture of the vertebral body by extension of the spine (as in the usual "two table" method) will be likely to push the upper vertebra forwards and damage the spinal cord.

When there is paraplegia or other evidence of injury to the cord or cauda equina a fracture-dislocation should be suspected and will probably be recognised at once. If there is no damage to the cord, or anyhow no obvious damage, the presence of a fracture-dislocation can only be detected by careful scrutiny of good X-ray films. In the lateral view it may be possible to see that the upper vertebra is a little forward on the lower, but it is the antero-posterior view which discloses a fractured lamina or rotational deformity with a "locked" inter-articular process. (See Fig. 83.)

**Treatment.** The treatment of spinal injuries with paraplegia will be described in a later section. When there is no evidence of damage to the cord the method of treatment of a fracture-dislocation in the dorsal or lumbar region depends on whether or not the vertebral processes and articular facets have become locked. In any case of fracture-dislocation the patient must be handled with the greatest care. He should be kept lying absolutely flat and neither flexion nor extension of the spine must be allowed before everything is ready for reduction.

When there is no "locking" the deformity is reduced by extension. The patient is given an anæsthetic while still lying prone and the spine is extended very gently and gradually by raising the legs from the table. This is done by means of a block and pulley suspended from a hook in the ceiling with suitable straps and tackle for fastening to the legs. The actual reduction is usually easy and should be confirmed by an X-ray taken in the theatre. A plaster jacket is then applied with the back still hyperextended and the patient is returned to bed.

When the articular facets are locked they must be reduced by an open operation The procedure is comparatively simple The region of the injury is exposed and the lower articular process, which now lies superficial to the upper is removed with bone cutting instruments It is then safe to extend the spine by hoisting the legs and the upper vertebra will slide back into its place It is not necessary always to remove the whole of the lower articular process provided enough is taken away to allow extension of the spine without impaction The wound is closed and a plaster jacket applied in the usual way After a fracture-dislocation it is often advisable to fuse the affected region of the spine by a formal bone grafting operation a month or six weeks after the accident

## Injuries in the Cervical Region

COMPRESSION FRACTURES Flexion injuries to the neck will produce compression fractures similar to those which occur in the dorsal and lumbar regions The sixth and seventh cervical vertebræ are those usually affected. In some individuals it is difficult to take a clear X ray film of the body of the seventh cervical vertebra and injuries to this bone are often missed

Provided there is no dislocation compression fractures in the cervical region are not usually complicated by cord injury Lesions of the cervical nerve roots may occur and lead to characteristic pain radiating into the arm with maybe weakness or paralysis of certain muscles in the upper limb

**Treatment** Consists in extension of the neck and immobilisation in a plaster cast known as a Minerva jacket It often proves impossible to overcome wedging of the vertebral body The plaster is applied with the patient supine and his head neck and thorax projecting over the end of the table A well greased narrow plank of thin wood supports the trunk while the head and arms are held by assistants The cast includes a band of plaster round the forehead and must be moulded under the chin to preserve hyperextension of the neck. The trunk is included as far

as pelvis ribs but the shoulders and arms are left free This plaster is naturally irksome at first but most patients soon settle down and manage to get about very well The fractured vertebra is usually consolidated in three or four months

DISLOCATIONS AND SUBLUXATIONS It is only in this region of the spine that dislocation is at all likely to occur without facture of some part of the bone The dislocation may be unilateral or bilateral. In the former case the head and neck are tilted to one side the ear being depressed on the affected side and the chin rotated away from it Bilateral complete dislocation is likely to produce a fatal injury to the spinal cord

The most usual injury is a forward subluxation between the fifth and sixth cervical vertebræ The diagnosis is established by careful examination of lateral X ray films There may be evidence of a cervical root lesion

**Treatment** Unilateral dislocation and bilateral sub luxation can usually be reduced by manual traction on the head followed by extension of the neck If this method fails or the patient is too ill for manipulation under general anæsthetic the displacement can be reduced by more gradual traction, applied through a skull calliper Once the deformity has been corrected a plaster cast is applied as in the case of compression fractures The dislocation is usually stable after eight weeks and the plaster can then be discarded.

FRACTURE DISLOCATION Just as in the dorsal and lumbar region, compression fracture of a vertebral body in the neck may be accompanied by rupture of the interspinous ligaments or fracture of the neural arch so that dislocation takes place It is unusual for a more severe injury of this type to occur without damage to the spinal cord or cervical nerve roots and complete section of the cord is unfortunately common.

**Treatment** If the patient is well enough and there is not a serious injury to the cord the displacement can be reduced by manipulation under anæsthetic Traction is provided by a special head harness (Glisson s sling) which can be attached to the surgeon s waist by cord or a strong

bandage By leaning backwards the surgeon can produce considerable traction whilst at the same time his hands are left free to rotate and extend the head and neck This can be carried out conveniently on an ordinary operating table with the head piece dropped so as to be out of the way and with the shoulder pieces in position to act as counter traction while the head is being pulled The operation is completed by the application of a Minerva plaster If the patient is not well enough for a general anæsthetic and manipulation—this is always the case when there is a cord lesion—reduction must be attempted by more gradual traction. The scalp is shaved and under local anæsthetic a special calliper is introduced into the outer table of the skull The caliper is then securely fixed by cord to the head of the bed which is raised about a foot The neck is suitably hyperextended by placing behind it a sandbag covered with a small thin pillow The pull on the neck is provided by the patient s weight sliding down the bed It is sometimes more effective to use a pulley at the head of the bed and to produce traction by suspending weight from the caliper If a skull caliper is not available Glisson s sling may be used as a temporary substitute but this method is extremely uncomfortable and pressure sores will soon develop beneath the chin

Skull traction should be successful in reducing the fracture dislocation within a few days traction may then be continued for two or three more weeks until it is safe to apply a plaster without fear of re-displacement

## Dislocation and Fracture dislocation with Injury to the Spinal Cord

It is only when there is a dislocation or fracture-dislocation of the vertebræ that the spinal cord is likely to be injured When one vertebra is displaced forwards on a lower one the cord may be compressed between the neural arch of the upper one and the posterior part of the body of the lower

The cord may be completely crushed only the dura mater remaining intact or the cord may be compressed without there being much actual macroscopic destruction

It is often impossible to tell in the early stages whether the cord has been compressed or destroyed for with either there may be a widespread paralysis and loss of sensation with paralysis of sphincters Unless there has been a complete transection of the cord some recovery will take place sooner or later

Management of Cases of Spinal Cord Injury The first considerations are to overcome shock and to prevent further damage to the cord which would convert what may be only an incomplete lesion into a complete transection.

As soon as the condition of the patient will allow it *some investigation of the cord lesion* should be made Detailed neurological examination is seldom feasible but the following points can be established quickly (1) the level of sensory loss to pin prick testing (2) the condition of the tendon reflexes (3) which muscles are paralysed and (4) the state of the bladder

The *treatment of the injury to the spine* will require consideration. With few exceptions the injury to the spinal cord takes place at the time of the accident and is not relieved in any way by subsequent treatment of the vertebral displacement However there is no doubt that for orthopædic reasons alone the dislocation or fracture-dislocation should be reduced so that the stability of the back is restored Whatever may be the final state of paralysis there is no reason why the patient's disablement should be increased by a deformed and painful spine The spinal deformity should be dealt with as soon as the condition of the patient is satisfactory and adequate facilities are to hand

The method of choice for dislocation and fracture dislocation in the cervical region is to apply a skull caliper and to reduce the displacement by traction In these cases of cervical injury a plaster bed is not required When the injury is in the dorsal or lumbar region treatment will depend on whether there is locking of the articular facets If there is an open reduction is essential If there is not the deformity is overcome by the leg hoisting method already described When reduction has been completed a

plaster bed is made which extends from the neck to the level of the knees The bed is dried rapidly, and the patient is returned in it to the ward This must be regarded as an emergency bed and in a week another bed fitted with a proper wooden keel and a turning case will be required

In almost all these cases there is retention of urine The *bladder* must never be allowed to remain distended as this will encourage the onset of cystitis The possible treatments are repeated catheterisation tying in a catheter doing a suprapubic cystotomy or expressing the urine by pressure on the bladder Many apparently conflicting statements have been made as to which is the best of these methods Manual expression of the urine is a potentially dangerous method and should be abandoned If the urine is already infected suprapubic cystotomy is essential In the early stages when the urine is clean repeated catheterisation or the tied in catheter attached to a drainage apparatus are both justifiable measures but on the whole suprapubic cystotomy is the method of choice If control of the sphincter is regained the suprapubic wound will soon close and nothing has been lost It is often possible to do the suprapubic drainage operation, when the spinal deformity is reduced The opening into the bladder must be placed high up on the fundus and the self retaining catheter should be attached to some form of closed circuit drainage apparatus so that the bladder may be kept reasonably full and thereby prevented from becoming contracted The urine must be kept acid in reaction and courses of sulphonamide or penicillin may be necessary to deal with the attacks of infection and cystitis

Paralysis of the sphincter makes *management of the bowels difficult* Daily enemata are advisable in the early stages combined with the judicious administration of laxatives *Treatment of the paralysed limbs* should begin early The principles of treatment are the same as in paralysis due to anterior poliomyelitis or a peripheral nerve lesion. Light easily removable plaster splints are required to overcome footdrop The joints must be prevented from becoming stiff by daily passive movements Paralysed muscles must

be protected from being overstretched and recovering muscles will require re-educational exercises strengthening exercises and electrical treatment *Pressure sores* are extremely likely to develop The greatest care must be taken of the back and sacrum and especially of the heels which are sometimes overlooked If a plaster bed is being used a turning case is provided so that the patient can be rolled over and his back treated once a week. The heels can be treated more often. Sores are not caused by a plaster bed unless it is wrongly made and the appearance of a sore on the buttock is not by any means an indication for dis continuing this method of treatment In fact on many occasions sores have been cured by putting the patient into a plaster bed instead of nursing him on a rubber mattress or water bed

Finally attention must be given to the patient s morale Those with lesions of the cervical region and quadriplegia seldom live long but when the lesion is at a lower level the paraplegic patient can be reassured that at the worst he will be able to get about in a wheeled chair He has at least his hands and arms and head with which to earn a living When the vertebral lesion has become consolidated and stable the plaster bed can be discarded and the patient is then encouraged to sit up As soon as possible he will be allowed out of bed It is hardly necessary to say that occupational therapy is of the utmost value at all stages in the management of these cases

**Indication for Operation in Spinal Cord Injuries** There are but few occasions in which operation can do the least good. Cases of fracture-dislocation with locking of the articular facets require operation and this has already been described. Operation may be indicated when there is an increasing paraplegia due to hæmorrhage into the spinal canal In cauda-equina lesions and cervical injuries when there is evidence of localised compression of a nerve root this can sometimes be relieved by operation. In compound injuries it may be necessary to remove a foreign body or sequestrum before infection will clear up

## Chapter XXVI

# FRACTURES OF THE RIBS AND STERNUM

### Fractures of the Ribs

This is a common injury and may result from indirect violence the whole chest being crushed and a number of ribs fractured or from direct violence there being a blow on one or more ribs There is tenderness over the site and crepitus may be felt or heard with the stethoscope as the patient breathes In the majority of cases there are no serious complications but, with a fracture of the ribs due to a severe direct blow the pleura may be injured and the lung penetrated As a result of this pneumo or hæmo-thorax or surgical emphysema may result With the latter the characteristic crepitus of air in the subcutaneous tissues will be felt and the condition may spread over the whole of the chest even up to the neck and down to the abdomen.

**Treatment** Although it is impossible to immobilise completely a fracture of a rib because of respiratory movements bony union always occurs readily and usually in good position Union will occur if no treatment is carried out, but a fractured rib causes considerable discomfort at each respiratory movement so that the chest should be strapped in order to make the patient more comfortable

If instead of strapping only the injured half of the chest as is often the custom bands of two-inch strapping are put completely round the chest so that the ends overlap, the patient will be much more comfortable because only by this means are movements of the bony chest wall really prevented. Respiratory movements are continued without difficulty by the diaphragm As each band of strapping is put on it should not be tightened until the chest is in a position of full expiration Strapping should be left on for three weeks after which the patient will have very little discomfort on breathing

A pneumo- or hæmo-thorax, unless large, is best left alone. A large amount of air or blood compresses the lung and should be removed by aspiration after a few days. Although *surgical emphysema may spread to a considerable extent it* will eventually subside spontaneously and requires no treatment.

## Fractures of the Sternum

Although in an exposed position, the sternum is not commonly fractured. In practice fractures are seen mostly in the upper part particularly the manubrium, which sometimes may be separated from the body of the bone. Fissured fractures may occur in various directions With most fractures of the sternum there is no displacement but sometimes when the fracture is transverse one fragment gets displaced backwards and tucked in under it so that reduction is not easy In such a case it may be necessary by open operation, to get a small lever in between the fragments to effect reduction. In the majority of cases it is sufficient to treat a fractured sternum by securely supporting the chest with strapping as with fractures of the ribs. The only disability the patient has is pain on movement and this is relieved by the strapping, providing it completely encircles the upper part of the chest. There is no permanent disability and after three weeks the strapping may be removed, but vigorous games should not be indulged in for a further period of three weeks.

## Chapter XXVII

# FRACTURES OF THE FACIAL BONES

For the purpose of description the facial skeleton can be divided into two components—the mandible and the middle third of the face which includes that area which lies between the supraorbital ridges and the upper teeth

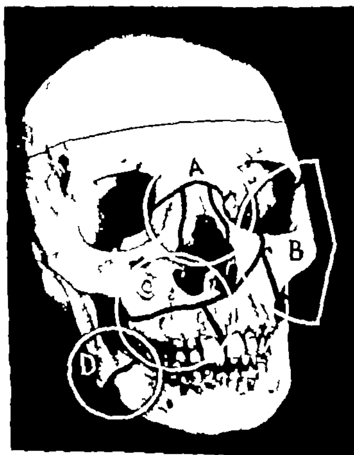



Fig 64. A typical distribution of fracture lines in a crush injury of the face:
(a) Naso-maxillary fracture.
(b) Malar maxillary fracture
(c) Guerin's fracture.
(d) Fracture through the angle of the mandible.

FRACTURES OF THE MIDDLE THIRD These occur as a result of direct violence, displacement being related only to the direction and degree of the trauma Three main categories of fracture occur —

(1) Naso maxillary fractures in which depression and/or deviation of the nasal arch exists with concomitant crumpling of the septum If seen early enough before œdema appears the deformity is obvious Immediate reduction is indicated under endo tracheal anæsthesia Reduction is most easily performed by Walsham s and Ash s forceps or in an emergency by the introduction of a blunt instrument such as a urethral sound. The arch can then be moulded to shape over the instrument

(2) Malar maxillary fractures in which the brunt of the force is taken by the malar bone or the zygomatic arch. The malar itself is rarely comminuted, and more often it is displaced *en masse* rotation tilting and direct depression resulting With severe trauma the orbital floor may be shattered with prolapse of the globe Some degree of injury to the extrinsic muscles will occur—notably the inferior oblique and the patient may complain of diplopia which may become permanent if the fracture is not promptly reduced The method of reduction depends upon whether the malar itself is involved or the zygomatic arch If the former the antral approach is indicated The antrum can be entered by a Caldwell luc the forefinger introduced into the cavity and the orbital floor ironed out The malar can then be elevated. Both the orbital floor and the malar bone can be held in position by an antral pack which is built up by the introduction of half inch ribbon gauze soaked in Whitehead s varnish This is retained for ten to fourteen days If the fracture involves the zygomatic arch Gillies approach is indicated. Here a small incision is made behind the hair line in the temporal fossa The incision is deepened to the body of the temporal muscle A Bristow s or Howarth s elevator can then be slid down below the fascia and beneath the arch of the zygoma Elevation will then effect reduction Fixation is rarely required as the bone can usually be re-impacted

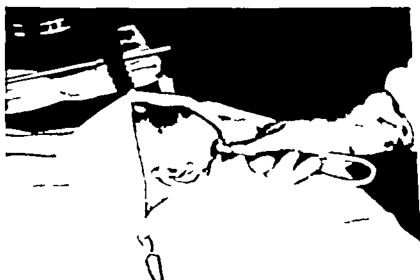


Fig. [illegible] Gillies' Approach in elevation of the zygomatic arch.

jaw may be completely mobile usually the result of a downward blow or may be impacted into the antral superstructure as a result of upward force These fractures always result in some degree of mal-occlusion—usually an open bite deformity The mobility can be determined by taking the pre maxilla between the finger and thumb and exerting an up and down movement It is essential to reduce the fracture and to obtain immobilisation (see Fracture of the Mandible) Disimpaction can be effected by the aid of Lion forceps one blade being placed on the palatal surface and one in the buccal surface A firm grip is then taken and the bone shaken loose by exerting a strong forward traction combined with a rocking movement

### Fractures of the Mandible

The mandible is fractured by both direct and indirect violence The lines of fracture run through the body or the

FRACTURES OF THE MIDDLE THIRD These occur as a result of direct violence displacement being related only to the direction and degree of the trauma. Three main categories of fracture occur —

(1) Naso-maxillary fractures in which depression and/or deviation of the nasal arch exists with concomitant crumpling of the septum If seen early enough before œdema appears the deformity is obvious Immediate reduction is indicated under endo-tracheal anæsthesia Reduction is most easily performed by Walsham s and Ash s forceps or in an emergency by the introduction of a blunt instrument such as a urethral sound The arch can then be moulded to shape over the instrument

(2) Malar maxillary fractures in which the brunt of the force is taken by the malar bone or the zygomatic arch The malar itself is rarely comminuted and more often it is displaced *en masse* rotation tilting and direct depression resulting With severe trauma the orbital floor may be shattered with prolapse of the globe Some degree of injury to the extrinsic muscles will occur—notably the inferior oblique, and the patient may complain of diplopia which may become permanent if the fracture is not promptly reduced The method of reduction depends upon whether the malar itself is involved or the zygomatic arch If the former the antral approach is indicated The antrum can be entered by a Caldwell luc the forefinger introduced into the cavity and the orbital floor ironed out The malar can then be elevated. Both the orbital floor and the malar bone can be held in position by an antral pack which is built up by the introduction of half inch ribbon gauze soaked in Whitehead s varnish. This is retained for ten to fourteen days If the fracture involves the zygomatic arch Gillies approach is indicated. Here a small incision is made behind the hair line in the temporal fossa The incision is deepened to the body of the temporal muscle A Bristow s or Howarth s elevator can then be slid down below the fascia and beneath the arch of the zygoma Elevation will then effect reduction. Fixation is rarely required as the bone can usually be re-impacted

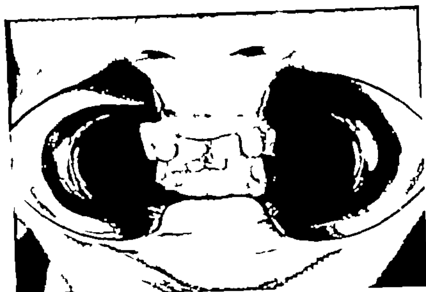


FIG 86. Emergency type of fixation—inter-dental wiring by the eyelet method



FIG 87 Skeletal pin fixation by modified Roger Anderson Pins.

are few standing teeth present or where the posterior fragment proves to be edentulous The pins are a modification of Roger Anderson s and two *cross pins are introduced into* each fragment Reduction is then effected and the two pins

ramus at almost any situation but three are common and are the result frequently of indirect violence in the form of a blow applied to the chin They are—fracture of the condylar neck fracture at the angle often involving the socket of the third molar and fracture through the region of the mental foramen Fracture of the condylar neck may occur without any displacement of the head of the condyle in which case there is a simple transverse fracture with little disability so much so that it may pass undiagnosed by both patient and surgeon However in some instances there is a fracture dislocation in which forward displacement and rotation of the head of the condyle occurs In these cases there are usually signs and symptoms pointing to a fracture and the patient will complain of pain and trismus and on opening the mouth it will be observed that there is displacement of the body of the mandible to the affected side The fractures should be confirmed by radiograph

Fractures in the region of the angle may show gross displacement depending on the line of fracture and in unfavourable cases the posterior fragment is pulled upwards and inwards by the internal pterygoid. The fracture is almost always compound into the mouth through the socket of the third molar and there will be clinical signs such as swelling pain and mal-occlusion It may be possible to palpate the deformity externally or find evidence of the internal displacement by inspecting the inside of the mouth

**Treatment** Reduction and immobilisation are indicated in all these fractures and the help of a dental surgeon should be enlisted. Essentially in both fractures of the maxilla and of the mandible the opposite and uninjured jaw is used as a splint First aid immobilisation can be obtained by the Barton Bandage or the E.M.S type head harness with an elastic chin strap However more stability is obtained by the eyelet method of inter-dental wiring using either 0·5 mm soft brass or 0·35 mm soft stainless steel wire More permanent fixation however should always be used and where sufficient teeth are present it is recommended that the cast metal dental cap splint be employed External pin fixation is sometimes advocated in those cases where there

## APPENDIX

(1) Percivall Pott
(2) Abraham Colles
(3) Robert William Smith
(4) Hugh Owen Thomas
(5) Edward Hallaran Bennett

### Percivall Pott 1714–1789

PERCIVALL POTT was born on January 6th, 1714 in Threadneedle Street where the Bank of England now stands His father also Percivall a scrivener in the city died when the young Percivall was but three years old The Bishop of Rochester a distant relative of his mother patronised the boy and sent him to school at Darenth in Kent

At the age of fifteen and a half Percivall Pott began a seven years apprenticeship to Mr Nourse one of the two surgeons of St Bartholomew s Hospital On September 7th 1736 he received his diploma and practised in the City as a surgeon living in Bow Lane He was elected assistant surgeon at St Bartholomew s Hospital in 1745 and in 1749 became full surgeon which appointment he held until 1787 when he was seventy three years of age

On a frosty morning in 1756 Pott was thrown from his horse in what is now the Old Kent Road He sustained a compound fracture of the tibia and was carried across London Bridge to his house in Watling Street a door purchased on the spot being used as a stretcher Amputation was decided upon, but at the last moment Pott s old teacher Nourse arrived and advised conservative treatment which proved successful.

Owing to enforced inactivity Pott then began to write and published many important original works It was not until 1768 that he published his work on Fractures and Dislocations in which the description of the fracture-dislocation at the ankle known by his name occurs

are joined by locking bars However it is not considered a method of choice and wherever possible the dental cap splints should be used in preference

*Dislocation of the Temporo Mandibular Joint* In some people the jaw dislocates with great ease and a recurrent dislocation may occur Dislocation usually takes place while opening the mouth widely as in yawning or it may be caused by the too vigorous use of a gag or by clumsy dental manipulations The dislocation may be uni lateral or bi lateral, but in either case the condyle of the jaw is displaced forwards on to the articular eminence in front of the articular fossa of the temporal bone The patient is quite unable to shut his mouth which is wide open If the dislocation is uni lateral the jaw is displaced towards the opposide side

The condition known as Clicking Jaw where there is *an internal derangement of the temporo manibular joint* the result of a congenital deformity of, or injury to the intra articular cartilage must not be mistaken for a dislocation.

**Treatment** A dislocation should be immediately reduced This can usually be done without an anaesthetic. The classical method is simple and effective The surgeon's thumbs are protected by wrapping a bandage round each They are then placed far back on the inferior ramus of the jaw on the molar teeth while the fingers grip the jaw from *below outside* *With the jaw thus under control the thumbs* press it downwards while the fingers raise the point of the jaw upwards this causes the condyles to slip back into the joint socket There is immediate relief of pain and the patient is able to move the jaw there is however some pain and perhaps swelling for a few days except in those cases where it is a recurrent dislocation. The patient should avoid opening the mouth widely and abstain from eating hard food for three weeks

a comparatively short article it has been a standard and much read work of reference on this subject ever since

## Robert William Smith 1807–1873

ROBERT WILLIAM SMITH (Smith s fracture of wrist) was the first Professor of Surgery at Trinity College Dublin He was also a surgeon at Richmond Hospital Dublin In addition to his practical achievements in surgery, he was very widely read and his professional lectures were unique for the clear and brilliant style of their delivery

His merits of style were as high in his written as in his spoken discourse and this was shown in his Treatise on *Fractures and Dislocations* which won a world wide reputation

He died from hepatic disease and ascites

## Hugh Owen Thomas 1835–1891

HUGH OWEN THOMAS belonged to the third generation in a family of bonesetters and was the first descendant to receive a medical education His grandfather Evan Thomas was the adopted child of a Welsh farmer of that name he as a child, having been washed ashore in Anglesey from a foundered ship His parentage was never traced but he was found to be of Spanish nationality Evan Thomas was brought up on the farm and showed a great aptitude for dealing with injured and sick animals Ultimately he became a well known bonesetter and his practice was carried on by his son, the father of Hugh Owen Thomas

Born in Anglesey in 1834 Hugh Owen Thomas was a nervous delicate child. Because of his ill health he lived with his parents at Rhos Colyn, and while at school there had an unfortunate accident to his left eye leaving a permanent scar contracting the lower lid On account of this unsightly scar he always wore a broad cloth cap with a shining brim well drawn down over the left eye He spent four years at New Brighton College at the age of seventeen he became apprenticed to his maternal uncle Dr Owen Roberts a surgeon at the Workhouse Infirmary, St Asaph and at

Leaving the City he lived first in Lincoln's Inn Fields and then near Hanover Square where he had a large and successful practice which he continued until his death from pneumonia in 1789

## Abraham Colles 1773–1843

ABRAHAM COLLES was born near Kilkenny and was educated at the endowed school there He entered the University of Dublin in 1790 and although he did not gain any brilliant academic honours his zeal for his work remained undiminished until his death in 1843

He became Professor of Anatomy and Surgery at Trinity College Dublin in 1804 and held the chair until 1836 during which time he did much to raise the status of the surgeon which at that time was much below that of the physician The standard of the work was brought to a very high level and the number of students at one time exceeded that of any similar institution in the United Kingdom.

He was twice President of the Royal College of Surgeons in Ireland—in 1802 and in 1830—and his portrait in oils and a marble bust are preserved in the College

A man of strong character amazing industry and equable temper as a surgeon he possessed all the essential qualifications of sound judgment and cool determination, combined with great manual dexterity as an author he expressed his ideas with simplicity and classical elegance and as a lecturer he spoke with easy fluency and much energy An enthusiastic and courageous teacher he was never afraid of admitting his errors to his students pointing out where he thought he had erred so that they might benefit by his experience

He was one of the first to deprecate the teaching of anatomy as a subject composed of several dissociated systems and his unfinished Treatise on Surgical Anatomy was a pioneer work.

His description of the Fracture of the Carpal Extremity of the Radius (Colles s Fracture) was first published in the *Edinburgh Medical and Surgical Journal* in 1814 Although

# INDEX

twenty-one years of age he entered the University of Edinburgh Two years later he went to University College London, gaining his membership of the Royal College of Surgeons in 1857 He joined his father in practice but his medical knowledge made it impossible for them to agree so the partnership came to an end He soon acquired a large practice having his own private hospital and a workshop for the making of his splints For thirty years he never took a holiday, and his usual working day was from 6 30 a.m. till midnight

Thomas was not a specialist in the modern sense of the word, he was a very busy general practitioner He was looked upon as a quack by the members of the medical profession of his own day This was very unfortunate because as Sir James Paget has said, Thomas dreamt of the redemption by the profession of the public from the wiles and snares of the bonesetter ' To-day he is chiefly remembered for his leg splint but he was the greatest orthopædist of all time, and gave to the profession many valuable orthopædic principles His own work was dominated by the principle of the necessity for rest in cases of inflamed or injured tissues

## Edward Hallaran Bennett 1837–1907

Edward Hallaran Bennett born in Cork in 1837 became surgeon to the Richmond Hospital Dublin.

He was the first to identify the typical fracture-dislocation of the base of the first metacarpal now known as Bennett s fracture of the thumb An intimate friend of Robert Smith he became his acknowledged successor as an authority on bone lesions of all kinds In 1879 he read an important paper on Colles s Fracture at a British Medical Association meeting at Cork.